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NATIONAL DAM INSPECTION PROGRAM. CAMPBELLS LEDGE DAM NDII.D.-PA--ETC(U)
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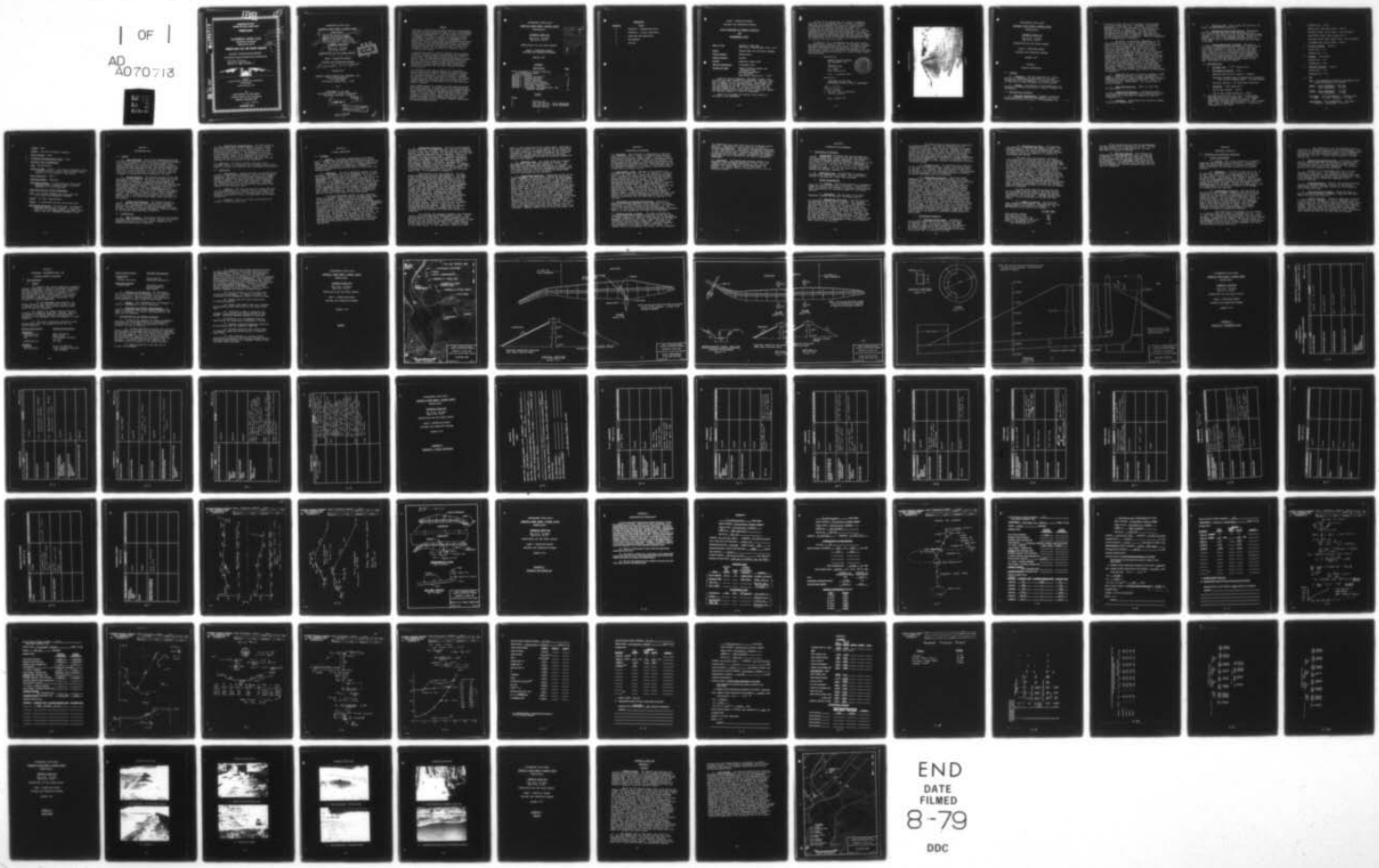

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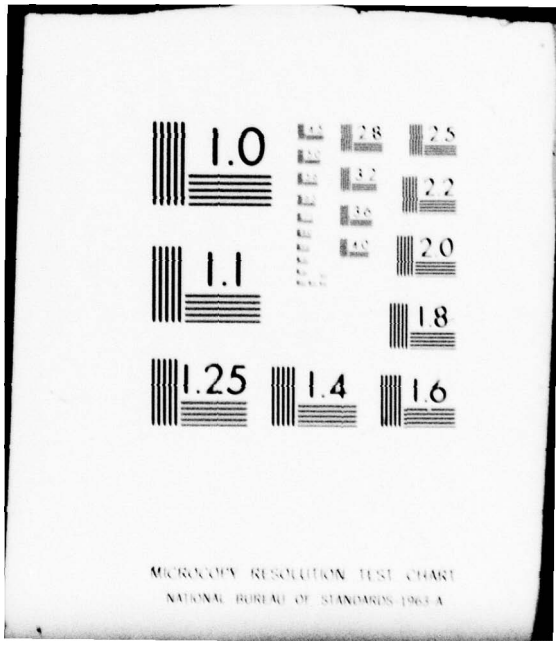
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SUSQUEHANNA RIVER BASIN
CAMPBELLS LEDGE CREEK, LUZERNE COUNTY

PENNSYLVANIA

CAMPBELLS LEDGE DAM

NDI ID NO. PA-00649
DER ID NO. 40-19

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Prepared by
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
Consulting Engineers
Harrisburg, Pennsylvania 17105

For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

411 004

JANUARY 1979

SUSQUEHANNA RIVER BASIN

CAMPBELLS LEDGE CREEK, LUZERNE COUNTY

PENNSYLVANIA

National Dam Inspection Program,
Campbells Ledge Dam (NDI-PA-00649)
(DER-40-19), Susquehanna River Basin,
Campbells Ledge Creek, Luzerne County,
Pennsylvania. Phase I Inspection Report.

CAMPBELLS LEDGE DAM

NDI ID No. PA-00649
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Baltimore, Maryland 21203

JANUARY 1979

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

SUSQUEHANNA RIVER BASIN

CAMPBELLS LEDGE CREEK, LUZERNE COUNTY

PENNSYLVANIA

CAMPBELLS LEDGE DAM

NDI ID No. PA-00649
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PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

JANUARY 1979

CONTENTS

PLATES

APPENDICES

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITION

AND

RECOMMENDED ACTION

Name of Dam:	Campbells Ledge Dam NDI ID No. PA-00649/DER ID No. 40-19
Owner:	Pennsylvania Gas and Water Company
State Located:	Pennsylvania
County Located:	Luzerne
Stream:	Campbells Ledge Creek
Date of Inspection:	9 November 1978
Inspection Team:	Gannett Fleming Corddry and Carpenter, Inc. Consulting Engineers P.O. Box 1963 Harrisburg, Pennsylvania 17105

Based on visual inspection, available records, calculations and past operational performance, Cambells Ledge Dam is judged to be in fair condition. The spillway can pass 43 percent of the Probable Maximum Flood (PMF) without overtopping of the dam. This is 86 percent of the spillway design flood. If the dam should fail, the resulting floodflows would only present a significant hazard. The spillway capacity is rated as inadequate.

There is no evidence of serious slope stability problems in the embankment.

In view of the concern for the safety of Campbells Ledge Dam it is recommended that, as soon as practical, the Owner make hydraulic and structural design studies to determine the measures necessary to repair the concrete in the spillway and stilling basin. It is also recommended that the Owner perform other measures, such as: removing trees and brush from the embankment; installing observation wells; monitoring bulges and wet areas; studying the suitability of the access road; and ensuring both that the outlet works valve is properly repaired and that a plug is available for upstream closure.

In addition, it is recommended that the Owner modify his operational procedures, such as: developing a detailed emergency warning and operation system; providing round-the-clock surveillance of the dam during periods of unusually heavy rains; and activating the emergency operation and warning system when warnings of a storm of major proportions are given.

Submitted by:

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.

A.C. HOOKE
Head, Dam Section

Date: 9 February 1979

Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

G.K. WITHERS
Colonel, Corps of Engineers
District Engineer

Date: 4 Mar 79

CAMPBELLS LEDGE DAM

Overview

SUSQUEHANNA RIVER BASIN

CAMPBELLS LEDGE CREEK, LUZERNE COUNTY

PENNSYLVANIA

CAMPBELLS LEDGE DAM

NDI ID No. PA-00649
DER ID No. 40-19

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JANUARY 1979

SECTION 1

PROJECT INFORMATION

1.1 General.

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Campbells Ledge Dam is two homogeneous earthfill embankments, both with reinforced-concrete core walls. The embankments are → over

located at either end of the reservoir, which extends in a north-south direction. The North, or upstream, Embankment is 590 feet long and 12 feet high at its maximum section. A canal flows into the reservoir at the east end of the embankment. The canal carries discharges from Falling Springs Dam. The flows are diverted into the canal to Campbells Ledge Dam by the Falling Springs Diversion Structure. The North Embankment has no outlet works or spillway.

The South, or downstream, Embankment is 750 feet long and 33 feet high at its maximum section. A morning glory spillway, whose variable crest elevation weir is 14 feet in diameter, is located near the middle of the embankment. The lowest weir crest is 3 feet lower than the top of the dam. The vertical spillway shaft converges and transitions to a horizontal 3-foot by 4-foot rectangular concrete conduit, which extends under the embankment to a stilling basin at the downstream toe of the slope. A valve house, containing valves for two 16-inch diameter cast-iron pipes, is located at the upstream end of the stilling basin. The pipes extend through the embankment to the reservoir. One of the pipes discharges into the stilling basin. The other connects to a water supply pipe that extends downstream. Various features of the dam are shown on the Plates at the end of the report and on the Photographs in Appendix D.

b. Location. The dam is located on Campbells Ledge Creek, 1.5 miles northwest of Duryea, Pennsylvania. Campbells Ledge Dam is shown on USGS Quadrangle, Pittston, Pennsylvania, with coordinates N41°21'45" - W75°47'25" in Luzerne County, Pennsylvania. The location map is shown on Plate 1.

c. Size Classification. Small (33 feet high, 281 acre-feet).

d. Hazard Classification. Significant hazard. Downstream conditions indicate that a significant hazard classification is warranted for Campbells Ledge Dam (Paragraph 5.1c.).

e. Ownership. Pennsylvania Gas and Water Company, Wilkes-Barre, Pennsylvania.

f. Purpose of Dam. Water supply for Pittston, Old Forge, and surrounding communities.

g. Design and Construction History. The dam was built between 1905 and 1906 under the supervision of J.H. Lance, Chief Engineer of the Spring Brook Water Supply Company. Mr. Lance also designed the dam. Except for the conversion of one of the emergency drawdown lines to a water supply line, no known modifications have been made to the dam.

h. Normal Operational Procedure. The pool is maintained at spillway crest elevation with excess inflow discharging through the spillway. Releases for water supply are drawn from the dam through the water supply pipe. When the pool is substantially below spillway crest elevation, inflows to the dam can be augmented by releases from Falling Springs Dam. These releases are diverted at the Falling Springs Diversion Structure on Falling Spring Creek and pass through a canal to the dam. The system is shown on Plate 1.

1.3 Pertinent Data.

a. Drainage Area. 0.3(1) square miles.

b. Discharge at Damsite. (cfs.)

Maximum known flood at damsite - unknown.

Emergency drawdown line at maximum pool elevation
(One 16-inch diameter pipe) - 30 (approximate)

Spillway capacity - 355 (Existing Conditions)

c. Elevation. (Feet above msl.)

Top of dam (design) - 1064.0

Top of dam (lowest elevation) - 1063.7

(1) Penn DER records before 1927 use 0.3 square mile. Later Records use 0.9 square mile. It is unknown from where this later figure was derived. GFCC checked the drainage area and found it to be 0.3 square mile. The 0.3 square mile includes 0.1 square mile intercepted by the canal.

Maximum pool - 1063.7

Normal pool (spillway crest) - 1061.0

Upstream invert outlet works - Not Available.

Downstream invert outlet works-1031.2.

Upstream invert water supply line - Not Available.

Streambed near outlet works - 1030.8

d. Reservoir Length. (Miles.)

Normal pool - 0.3

Maximum pool - 0.3

e. Storage. (Acre-feet.)

Normal pool - 214

Maximum pool - 281

f. Reservoir Surface. (Acres.)

Normal pool - 21.7

Maximum pool - 22.6

g. Dam.

Type - Two homogeneous earthfill embankments with reinforced-concrete core walls.

Length - North Embankment - 590 feet
South Embankment - 750 feet

Height - North Embankment - 12 feet
South Embankment - 33 feet

Top Width - (both embankments) - Concrete core wall - 2.5 feet. Earthfill - 10 feet.

Side Slopes - (both embankments) - Upstream - 1V on 2H. Downstream - 1V on 2H.

Zoning - None.

Cutoff - Core wall founded on bedrock.

Grout Curtain - None.

h. Diversion and Regulating Tunnel - None.

i. Spillway (south embankment).

Type - Morning glory

Length of Weir - Varies - 30.8 feet at elevation 1061.0 (control shifts to conduit near elevation 1062.0. Conduit is 4 feet high by 3 feet wide.)

Crest Elevation - 1061.0

Upstream Channel - Reservoir

Downstream Channel - A 3-foot wide by 4-foot high concrete conduit extending under the South Embankment to a stilling basin.

j. Regulating Outlets (South Embankment).

Type - Two 16-inch diameter cast-iron pipes for water supply and emergency drawdown.

Length - 140 feet (approximate).

Access - To downstream end and valve house only.

Regulating Facilities - For each pipe, two manually operated, gate valves in series. A by-pass with valve is provided between the right (water supply) and left (emergency drawdown) lines.

SECTION 2

ENGINEERING DATA

2.1 Design.

a. Data Available. Very little engineering data was available for review for the structure as originally designed. In a study performed in 1914 by the Pennsylvania Water Supply Commission, an account of design concepts, geology, construction materials and methods, and design features was prepared for the components of the dam from interviews with the Owner, visual inspection, and other sources. The 1914 study also included analyses for hydrology and hydraulics. A summary of the results of the analyses is on file.

b. Design Features. The various features of the dam are shown on the plates at the end of the report and on the photographs in Appendix D. The plates were prepared for this report from limited information gathered during the field inspection and from information in the 1914 Pennsylvania Water Supply Commission Report. The plates should not be considered definitive. The South Embankment plan and section are shown on Plate 2 and on Photographs A B, and D. The North Embankment is shown on Plate 3 and on Photographs E and F. The spillway is shown on Plate 4 and on Photographs B and C. Insufficient information was available to draw details of the outlet works pipes, which are shown on Photograph C.

c. Design Considerations. The spillway design is unique. Morning glory spillways are usually arranged so that the full circumference is available for discharge. However, the small conduit through the embankment will act as control for higher spillway discharges. The full effects of the spillway are described in Section 5.

2.2 Construction.

a. Data Available. Construction data for the original structure that is available for review, consists of the information contained in the 1914 report prepared by the Pennsylvania Water Supply Commission.

b. Construction Considerations. The 1914 report by the Pennsylvania Water Supply Commission raised concern about the construction of the original structure. Compaction was accomplished only by passing back and forth with horse-drawn scrapers. The embankment was placed in non-uniform layers. Other observations in this report, such as careful selection of embankment material and careful placing of the riprap indicate that some care was utilized in the construction of the embankment.

2.3 Operation. No formal records of operation were reviewed. Based on information from the Owner and the caretaker of the dam, all structures have performed satisfactorily.

2.4 Evaluation.

a. Availability. Engineering data was provided by the Division of Dams and Encroachments, Bureau of Water Quality Management, Department of Environmental Resources, Commonwealth of Pennsylvania and by the Owner, Pennsylvania Gas and Water Company. The Owner made available a caretaker for information during the visual inspection. The Owner also researched his files for additional information upon request of the inspection team.

b. Adequacy. The type and amount of design data and other engineering data is limited, and the assessment must be based on the combination of available data, visual inspection, performance history, and hydrologic and hydraulic assumptions.

c. Validity. There is no reason to question the validity of the available data.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. The overall appearance of the dam is good. However, some deficiencies were observed as noted below. A sketch of the dam with the location of some of the deficiencies is presented on Plate B-1. Survey information acquired for this report is summarized in Appendix B. During the inspection the pool was about 4.5 feet below the spillway crest.

b. Embankment. The South Embankment appears in good condition. The entire top of the embankment is at or above the design elevation as noted in Appendix B. Tire ruts, approximately 4 inches deep, were noted along the top of the embankment. No seepage or wet areas were observed on or downstream of the embankment. There is minor bulging of the riprap on the upstream slope about 4 feet below top of dam. There is a sparse cover of brush, about 1 inch in diameter, on the embankment except at both abutments on the upstream slope, where the brush is up to 2 inches in diameter and much thicker (Photograph A). Mature trees are growing at the toe of slope to the right of the outlet works.

The North Embankment appears in good condition. There is a sporadic cover of brush on the downstream slope of the embankment. Remains of previous brush cutting operations are at the downstream toe of the embankment. Near the west end of the embankment, the top of the embankment is 0.3 foot below the design elevation, as noted in Appendix B. The remainder of the embankment is at or above the design elevation. A 65-foot long by 15-foot wide wet area was observed near the middle of the embankment and 45 feet downstream of the toe (Photograph F). The soil in the wet area is soft. There are trees growing in the wet area. No standing water or seepage was observed in this area. On the day of the inspection, the canal from the Falling Springs Diversion Structure was flowing about 1 foot deep. The reservoir was being filled by releases from Falling Springs Dam.

c. Appurtenant Structures. The outlet works appears in good condition. The Owner reported that the 2 valves on the right line (water supply) had been re-built the previous spring. During these repairs, the upstream valve on the left line (emergency drawdown) became inoperable. Parts are presently on order for this valve. Although a bypass is available, the Owner declined to operate it; this would have allowed sediment to pass into the water supply line, which was in operation. Therefore, the operation of the emergency drawdown line was not observed. The pipes extend under pressure through the embankment. A submerged structure was observed to the right of the spillway. It is believed that the structure is an inlet for the water supply line. It is sketched in Appendix B.

The spillway is in fair condition. An iron fence surrounds the spillway (Photograph B). The upper 6 feet of the Morning Glory shaft appears to have been repaired previously and the concrete appears to be in good condition. Below this elevation, the concrete is severely scoured and spalled over most of the vertical shaft. A maximum spall depth of 0.5 foot was estimated, but the area was inaccessible for exact measurements. A small pipe, the purpose of which is unknown, extends through the right wall of the vertical shaft about 6 feet below the crest. Seepage was observed from this pipe. Seepage was also observed over the face of the shaft below this elevation. The elbow juncture of the vertical shaft and the horizontal conduit is also severely spalled. The conduit appears to have been rough-formed. The entire bottom of the conduit is severely scoured. The walls and roof of the conduit are in good condition except, at many points, the reinforcing bars are exposed. These bars are severely rusting and deteriorated. It appears that little concrete cover was provided for these bars during construction.

The spillway and emergency drawdown line discharge jointly into a stilling basin (Photographs C and D). The concrete bottom of this basin is almost completely scoured. The left wall of the basin has a shrinkage crack about 15 feet beyond the outlet works and another at the curved section of wall near the outlet works. There is spalling evident at the latter crack. At the right wall, there is a crack

about 15 feet downstream of the outlet works. Upstream of this crack, the wall is tilted towards the stilling basin. The total seepage at the downstream end of the conduit was estimated at 0.5 gpm, although it appeared that a greater quantity was seeping into the throat of the spillway. Some of the seepage may have been infiltrating through the bottom of the conduit.

d. Reservoir Area. The slopes along the reservoir are relatively flat, but much outcrop is visible. The watershed is undeveloped and uninhabited. It is owned and controlled by Pennsylvania Gas and Water Company. The canal that extends to the North Embankment was constructed in a manner such that flows overtopping the canal banks would not discharge into the reservoir.

e. Downstream Conditions. Downstream (north) of the North Embankment, the land slopes towards Falling Springs Creek. Immediately downstream (south) of the South Embankment, at the end of the stilling basin, a small amount of fill is piled. The stream beyond this extends for 0.8 mile down a narrow and steep valley. In this reach there is a small intake dam, which is considered abandoned by the Owner. Beyond this reach, the stream discharges into an abandoned strip mine. The east end of the strip mine is still being mined. This area is substantially higher in elevation than the abandoned portion of the strip mine. Water is ponded in the mine, which is transversed by an abandoned railroad bed. An access road extends along the south edge of the mine. The top of road is about 15 feet above the ponded water. Immediately south of the road is the Lackawanna River. No outlet from the mine to the river was observed. The access road to the dam extends from the north edge of the strip mine along Campbells Ledge Creek, which crosses under it in a culvert. Numerous erosion gullies cross the access road.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedure. The reservoir is maintained at spillway crest Elevation 1061.0. Water is normally drawn from the reservoir from the water supply intake. The water supply line extends through the outlet works and downstream to the Owner's distribution system. Flows into the reservoir can be augmented by discharges from Falling Springs Dam via the Falling Springs Diversion Structure. The upstream valve on the emergency drawdown line is normally open and the downstream valve is normally closed.

4.2 Maintenance of Dam. The dam is visited daily by a caretaker who checks the level of the reservoir, regulates valves in the valve house, checks the cholorination equipment, regulates the diversion structure gate and performs general maintenance on the system. The reservoir level is recorded daily and reports are mailed to the Owner's Engineering Department weekly. This information is used by the Engineering Department for regulating flows in the distribution system. The caretaker is also responsible for reporting any changes or deficiencies to the Owner's Engineering Department via two-way radio provided in the Owner's trucks. A Pennsylvania Gas and Water Company engineer makes a formal inspection of the dam each year, and reports are utilized when determining priority of repairs. Informal inspections are also made when an engineer is on the site.

4.3 Maintenance of Operating Facilities. There is no regular maintenance program for the operating facilities. Maintenance is performed when deemed necessary. In response to the dam inspection program of the previous year, the Owner is in the process of modifying his maintenance procedures. Details of the program have not been fully formulated.

4.4 Warning Systems in Effect. The Owner furnished the inspection team with a verbal description of both the chain of command diagram for Campbells Ledge Dam and the generalized emergency notification list that is applicable for all the Pennsylvania Gas and Water Company dams. The Owner said that during periods of heavy rainfall, available personnel are dispatched to the dams to observe conditions. All company vehicles are equipped with radios, and the personnel

can communicate with each other and with a central control facility. Evaluation of risk is made by the Owner's Engineering Department. The Owner's Engineering Department is also responsible for notification of emergency conditions to the local authorities. Detailed emergency operational procedures have not been formally established for Campbells Ledge Dam but are as directed by the Owner's Engineering Department.

4.5 Evaluation. The operational measures appear to be adequate. The maintenance generally is fair. The procedures used by the Owner for inspecting the dam are adequate, but needed repairs have not been made. In general, the warning system is adequate, but it is not in sufficient detail.

SECTION 5

HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. No design data was available for review. During 1914, a report on the dam was prepared by the Pennsylvania Water Supply Commission. The report estimated the maximum spillway discharge capacity at 420 cfs with control in the conduit and the top of embankment at design elevation. The total "K" value in the conduit was estimated at 1.56. A "K" value of 2.09, with a resulting maximum discharge of 355 cfs, was used in this report to analyze the spillway (Appendix C).

b. Experience Data. No hydrologic or hydraulic problems were reported by the Owner. He stated that no records of maximum pool levels were available.

c. Visual Observations.

(1) General. The visual inspection of Campbells Ledge Dam, which is described in Section 3, resulted in a number of observations relevant to hydraulics and hydrology. These observations are evaluated herein for the various features.

(2) Embankment. The low area on the North Embankment reduces the spillway discharge capacity.

(3) Appurtenant Structures. Once the valve on the emergency drawdown line is repaired, the emergency drawdown facilities should be adequate. Some capability is now provided by the bypass, but its operation was not observed. The Owner stated that there are various size plugs and an in-house diving capability available to plug the lines upstream. However, the Owner did not know if correct size plug was available. If it is available, then the closure facilities are deemed adequate. The Owner did not have information on the submerged structure near the spillway that was believed to be an inlet. It appeared that one pipe extends up the embankment to draw water from the upper levels of the reservoir.

The fence around the spillway has a potential of collecting debris. The various inspections by the Commonwealth note the fence but do not consider it a hazard. It acts as a personnel safety feature. Removing the fence around the lower part of the crest and providing a floating trash boom would reduce the debris collection potential. Because of the scour observed on the floor of the conduit and in the stilling basin, the potential of scour threatening the structures appears high. The scour is probably due to cavitational effects of flow through a morning glory spillway of unusual design.

(4) Reservoir Area. No conditions were observed in the reservoir area that might present significant hazard to the dam. It is apparent that inflow from the canal will be limited to its bank full discharge capacity. The assessment of the dam is based on existing conditions and the effects of future development are not considered.

(5) Downstream Conditions. Should the North Embankment fail, flood flows would discharge into Falling Springs Creek. A Phase I Dam Inspection Report was previously prepared for Falling Spring Dam. In that report, the conditions at the confluence of Falling Springs Creek and the Susquehanna River indicate that a significant hazard exists at that point. No other hazards exist on Falling Springs Creek. Should the South Embankment fail, flood flows would discharge through Campbells Ledge Creek to the strip mine. The abandoned intake dam is sufficiently small that it would provide no significant mitigating effects to the floodflow, nor would its failure substantially increase the hazards. The depth of ponding in the strip mine would increase from the floodflows. For certain conditions, the ponded water in the dam might overflow the access road along the south edge. If this occurred, there is a possibility of shallow flooding occurring in the active part of the mine. The downstream conditions indicate that a significant hazard classification is warranted for Campbells Ledge Dam. The access road to the dam may be impassable during periods of high runoff.

d. Overtopping Potential.

(1) Spillway Design Flood. According to the criteria established by the Office of the Chief of Engineers (OCE), the spillway design flood (SDF) for the size (small) and hazard potential (significant) of Campbells Ledge Dam varies between the 100 year flood and one-half of the probable maximum flood (PMF). The one-half PMF is selected as the SDF.

(2) Description of Model. The watershed was modelled with the HEC-1DB computer program. This program computes a PMF runoff hydrograph and routes the flows through both reservoirs and stream sections. In addition, it has the capability to simulate an overtopping dam failure.

The canal into the reservoir intercepts 0.09 square mile of watershed directly and, depending on the position of the sluice gate at the upstream end, it can also carry discharges from Falling Springs Creek. For this study, it was assumed that during the occurrence of the SDF, the canal would be conveying its bank-full normal depth capacity. Any additional inflows to the canal would overtop the canal banks and not discharge into the reservoir. The assumption of bank-full normal depth capacity is conservative because the equivalent volume of inflow is 1,300 acre-feet over the duration of the storm. This volume is equal to the total storage of Falling Springs Dam upstream plus 6 inches of runoff over the Falling Springs Dam drainage area. During the occurrence of the SDF, the average canal discharge would probably be less than the assumed bank-full discharge.

The SDF runoff from the uncontrolled part of the drainage area was added to the canal outflow. The resultant inflow was routed through the dam and downstream to the strip mine. Identical methods were used for various percentages of the SDF and canal inflow.

(3) Summary of Results. The following table summarizes the results. Selected parts of the program output are presented in Appendix C. The PMF rainfall at the site is 24.9 inches.

	1/2 PMF (SDF)
Total Runoff (inches)	11.4
SDF peak inflow (cfs)	636
Peak Outflow from dam (cfs)	586
Depth of overtopping of dam (ft.)	0.23
Depth of overtopping of strip mine downstream (ft.)	0.08

With the existing low area on the embankment, the dam can pass about 43 percent of the PMF. If the dam were raised to its design elevation, it could pass about 47 percent of the PMF.

(4) Spillway Adequacy. The criteria for rating the spillway adequacy of a dam is presented in Appendix C. Because the dam cannot pass the SDF without overtopping the spillway, capacity is rated as inadequate. If the embankment were raised to its design elevation, the dam would not pass the SDF without overtopping; the spillway capacity would still be rated as inadequate.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations.

(1) General. The visual inspection of Campbells Ledge Dam, which is described in Section 3, resulted in a number of observations relevant to structural stability. These observations are evaluated herein for the various features.

(2) Embankment. Tire ruts on the top of dam, if not repaired, can result in a lower elevation of the top of dam. Brush and trees on the embankment and at the toe are undesirable. The bulging of the riprap is probably caused by uneven grading during construction. The low area on the North Embankment is probably caused by uneven grading during construction, although a slight settlement of the embankment may have occurred. The wet area downstream of the North Embankment is not of major concern, as no seepage or standing water was observed.

(3) Appurtenant Structures. The conditions at the spillway are of concern. Plate 4 shows the structural dimensions of the spillway, as determined from the field inspection and from the 1914 Pennsylvania Water Supply Commission Report. The spalling is sufficiently severe in the vertical shaft that the integrity of the structure may be threatened if spalling continues. The embankment exerts earth pressure around the entire vertical shaft. There is also full hydrostatic loading. The seepage observed indicates that a piping potential may exist, although no evidence of piping was observed.

The conditions in the conduit are of concern. It is believed that the conduit is designed as a box. If it is, the scour observed on the bottom would lower its design strength. The deteriorated reinforcing has, in effect, reduced the design strength of the conduit. This conduit supports the embankment for most of its length. Failure of the conduit would create serious problems for the embankment and leave the dam without spillway facilities.

The conditions at the stilling basin are an indication of inadequate design and lack of maintenance. From review of the periodic inspection reports by the Commonwealth, the damage to the stilling basin appears to have occurred between 1941 and 1943. A major flood occurred in the area during 1942.

b. Design and Construction Data. No record of design data or stability analysis for the original structures was available for review. The structure was studied in 1914 by the Pennsylvania Water Supply Commission. No stability analysis for the structures was performed.

Analysis of the embankment stability is beyond the scope of this study. Also, sufficient data on the engineering properties of the embankment material would have to be acquired before the analysis could be performed. There is no evidence of any significant embankment slope stability problems.

c. Operating Records. Based on the operating records, there is no evidence that any features of the dam have experienced stability problems, except for the tilting of the stilling basin wall.

d. Post-Construction Changes. There have been no post-construction changes to Campbells Ledge Dam that would affect the structural stability.

e. Seismic Stability. Campbells Ledge Dam is located in Seismic Zone 1. Normally, it can be considered that if a dam in this zone has adequate factors of safety under static loading conditions, it can be assumed safe for any expected loading. However, since there are no formal static stability analyses, and since there is the potential of earthquake forces moving or cracking the concrete core wall, the theoretical seismic stability of this dam cannot be assessed.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety.

(1) Based on the visual inspection, available records, calculations, and past operational performance, Campbells Ledge Dam is judged to be in fair condition. The existing spillway will pass 43 percent of the PMF (86 percent of the spillway design flood) without overtopping of the dam. The failure of the dam will only present a significant hazard downstream. The spillway is rated as inadequate.

If the embankment were raised to its design elevation, the spillway would be able to pass 47 percent of the PMF. The spillway capacity would still be rated as inadequate.

(2) There is no formal stability analysis available for Campbells Ledge Dam. However, there is no evidence of problems presently threatening the stability of the embankment from the standpoint of slope stability.

(3) The visual inspection resulted in some deficiencies, which are summarized below for the various features.

Feature and Location	Observed Deficiencies
Embankment:	
Slopes and toe	Trees and brush
Upstream slope	Minor bulges
Top	Below design elevation & ruts
Downstream toe	Wet area
Spillway:	
Spillway	Scour and spalling
Stilling basin	Scour, cracking, spalling and movement

Feature and Location	Observed Deficiencies
Outlet Works:	
Valve	Being repaired
Closure facilities	Uncertain availability
Downstream Channel:	
Access road	Uncertain access during periods of high runoff.

b. Adequacy of Information. The information available is such that an assessment of the condition of the dam can be inferred from the combination of visual inspection, past performance, and computations performed prior to and as part of this study.

c. Urgency. The recommendations in Paragragh 7.2 should be implemented as soon as practical.

d. Necessity for Further Investigations. In order to accomplish some of the remedial measures outlined in Paragraph 7.2, further investigations by the Owner will be required.

7.2 Recommendations and Remedial Measures.

a. In view of the concern for safety of Campbells Ledge Dam, the following measures are recommended to be undertaken by the Owner, in approximate order of priority, as soon as practical.

(1) Perform additional hydraulic and structural design studies to determine the best method of repairing the spillway vertical shaft and conduit without decreasing the spillway capacity. The study should also address both the necessary repairs to the stilling basin and the suitability of removing the iron fence around the spillway. To increase the spillway capacity, the embankment should be raised to its design elevation.

(2) Remove brush and trees that are on or near the embankment.

(3) Install seven or more observation wells, or other instrumentation, downstream from the axis of the embankments. One well, or other instrumentation, should be located in the vicinity of the wet area. The others should be at appropriate locations to determine general water levels in the embankments. Data collected from observation wells or other instrumentation should be utilized in evaluating the stability of the structures and assessing piping potential. Continue to observe wet area downstream of embankments. If conditions worsen, appropriate action should be taken to control apparent seepage with properly designed drains.

(4) Monitor bulges at the upstream slope of the South Embankment. If changes are noted, an evaluation of the embankment stability should be made.

(5) Ensure that the outlet works valve is repaired properly.

(6) Ensure that proper plugs are available for upstream closure facilities on the outlet works pipe.

(7) Undertake a study to determine the adequacy of the access road during periods of high runoff. Undertake remedial measures as required.

b. In addition, it is recommended that the Owner modify his operational procedures as follows:

(1) Develop a detailed emergency operation and warning system for Campbells Ledge Dam.

(2) Provide round-the-clock surveillance of Campbells Ledge Dam during periods of unusually heavy rains.

(3) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system procedures.

SUSQUEHANNA RIVER BASIN

CAMPBELLS LEDGE CREEK, LUZERNE COUNTY

PENNSYLVANIA

CAMPBELLS LEDGE DAM

NDI ID No. PA-00649
DER ID No. 40-19

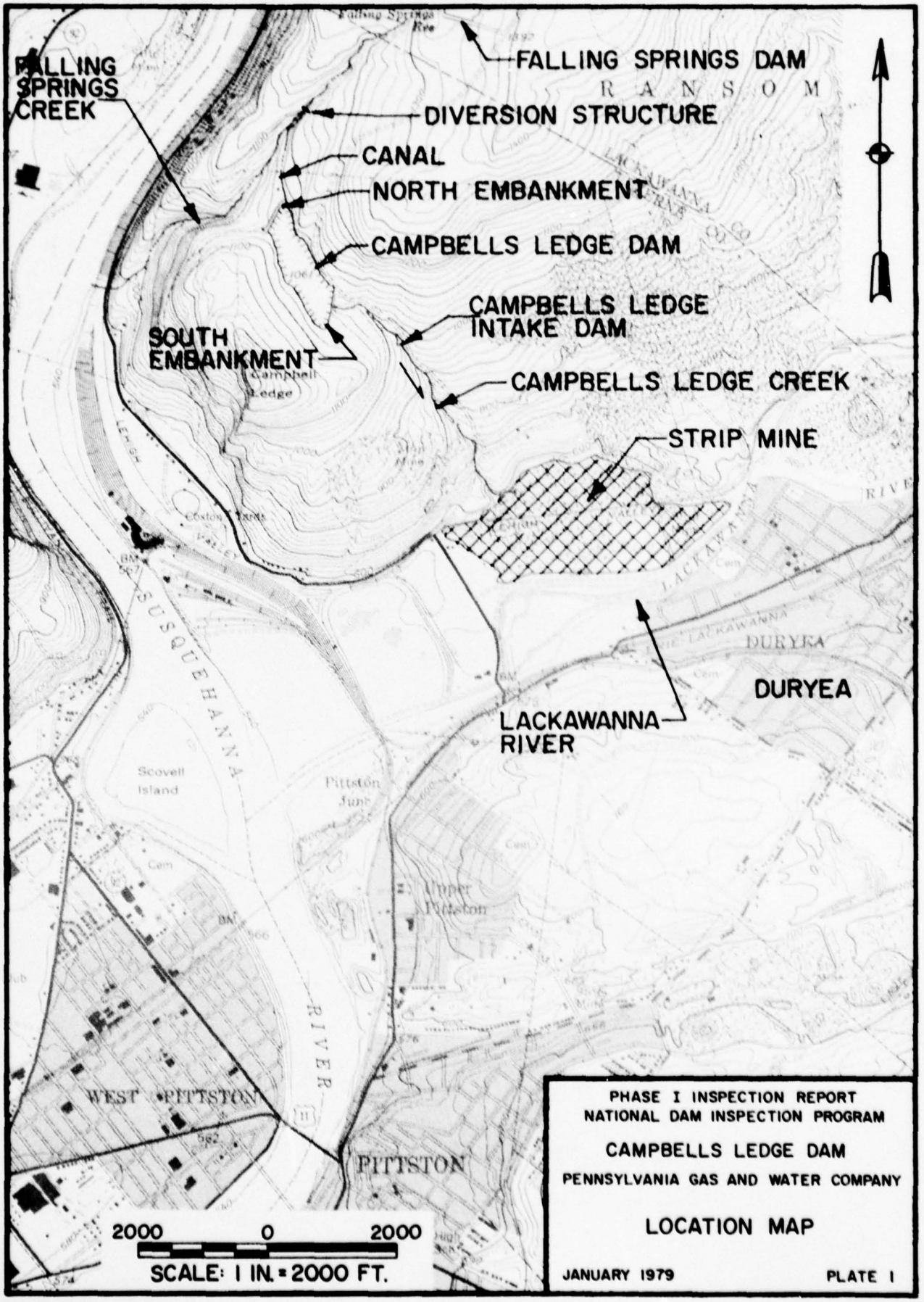
PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JANUARY 1979

PLATES



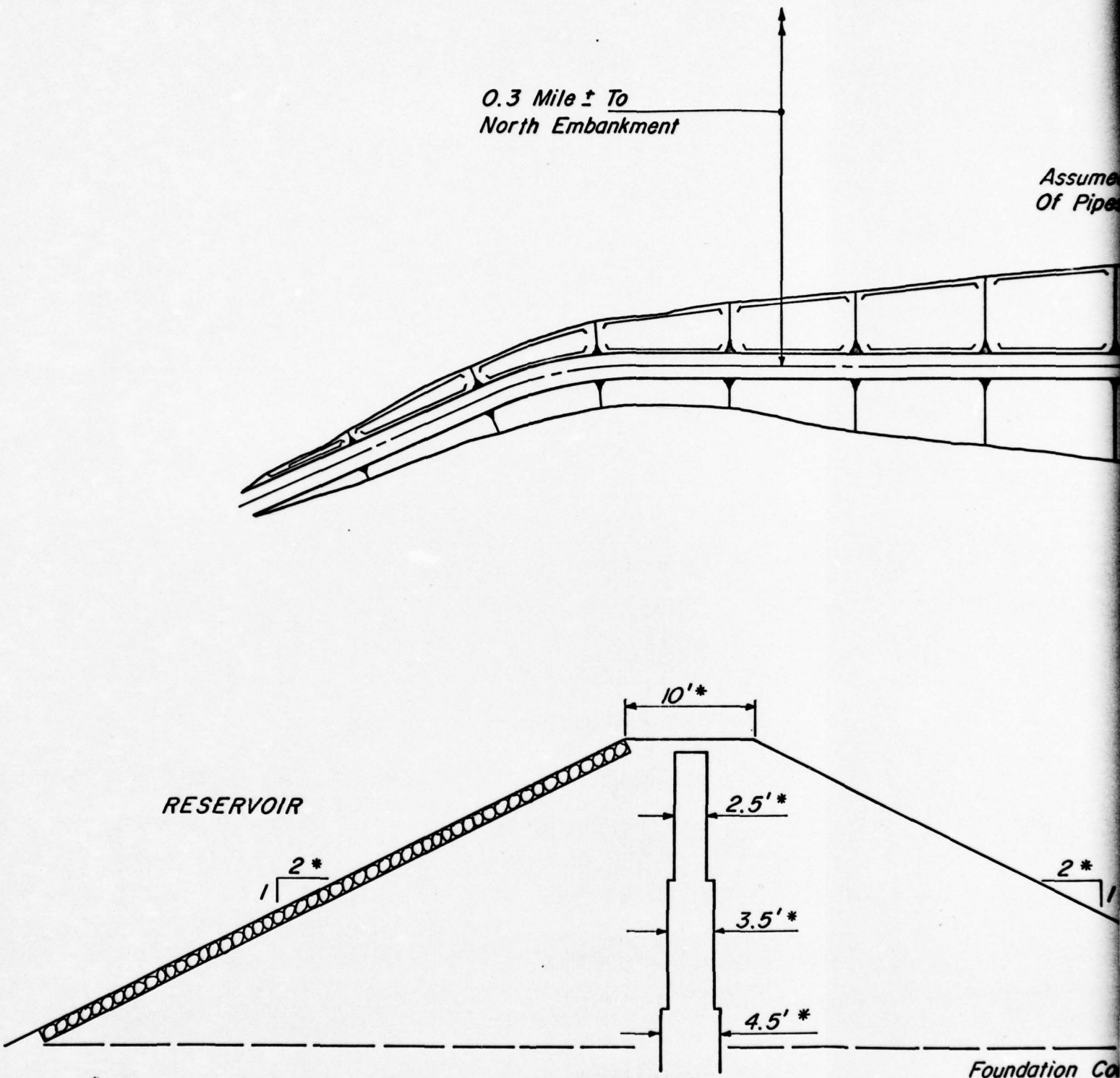
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

CAMPBELLS LEDGE DAM

PENNSYLVANIA GAS AND WATER COMPANY

LOCATION MAP

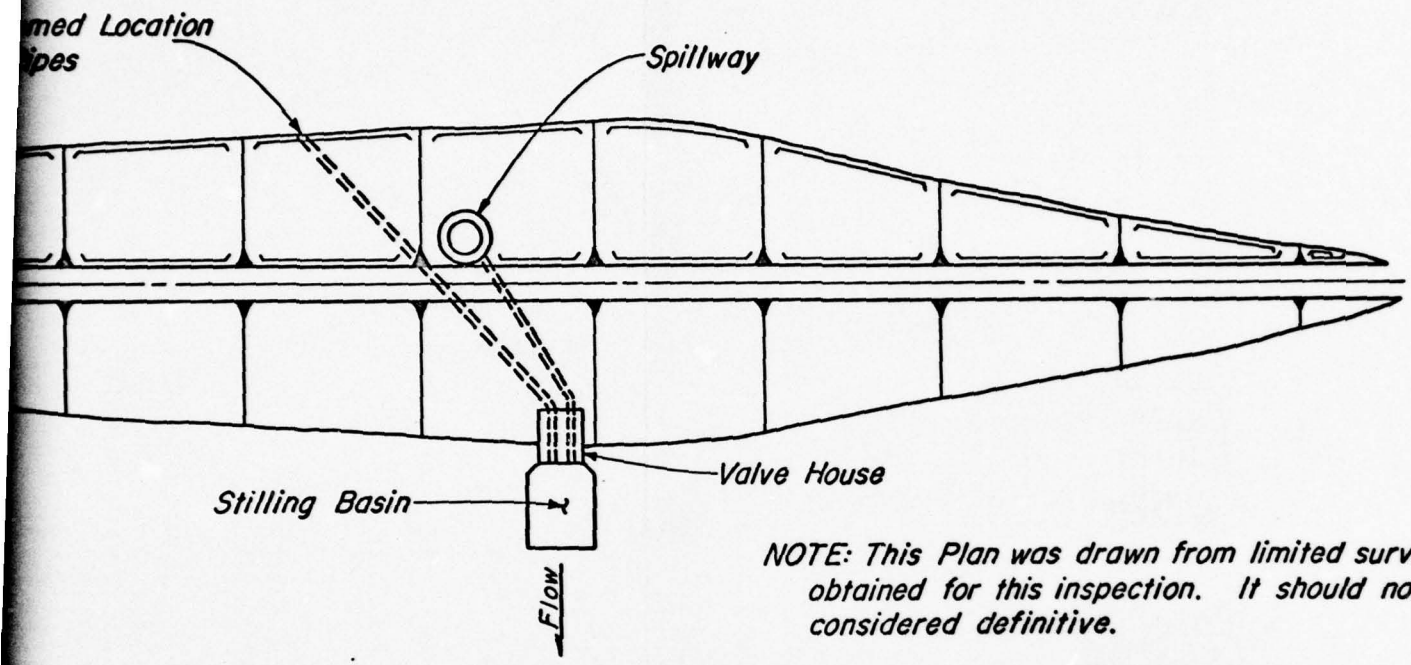
JANUARY 1979 PLATE 1



*Information obtained from Pennsylvania Water Supply Commission Report.

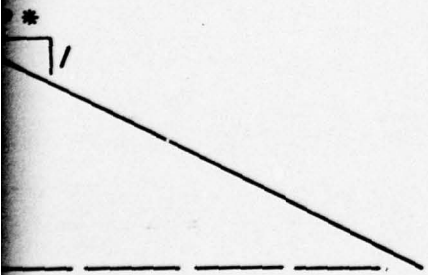
TYPICAL SECTION

SCALE: 1" = 10'



NOTE: This Plan was drawn from limited survey data obtained for this inspection. It should not be considered definitive.

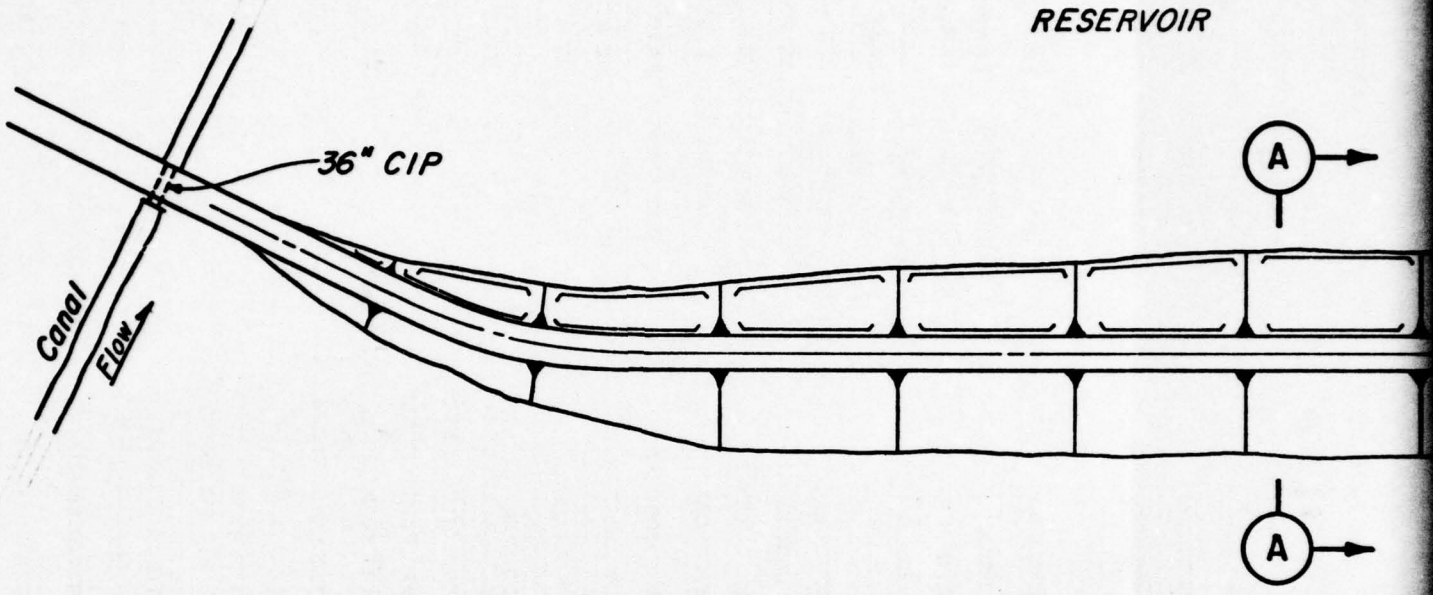
PLAN
SCALE 1"= 50'



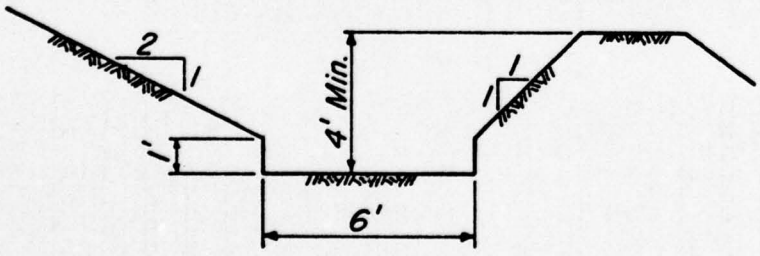
n Conditions Unknown

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
CAMPBELLS LEDGE DAM
PENNSYLVANIA GAS AND WATER COMPANY
SOUTH EMBANKMENT
PLAN AND SECTION
JANUARY 1979 PLATE 2

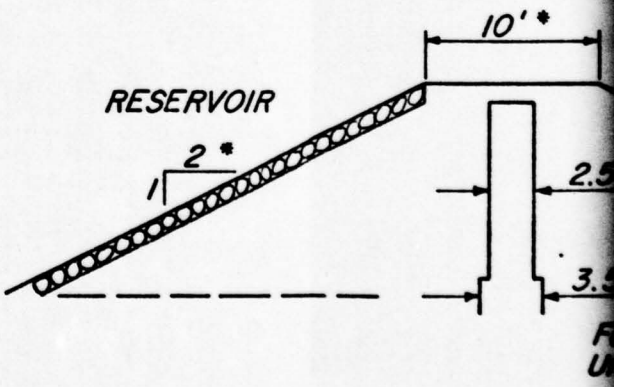
2



PLAN
SCALE: 1" = 50'

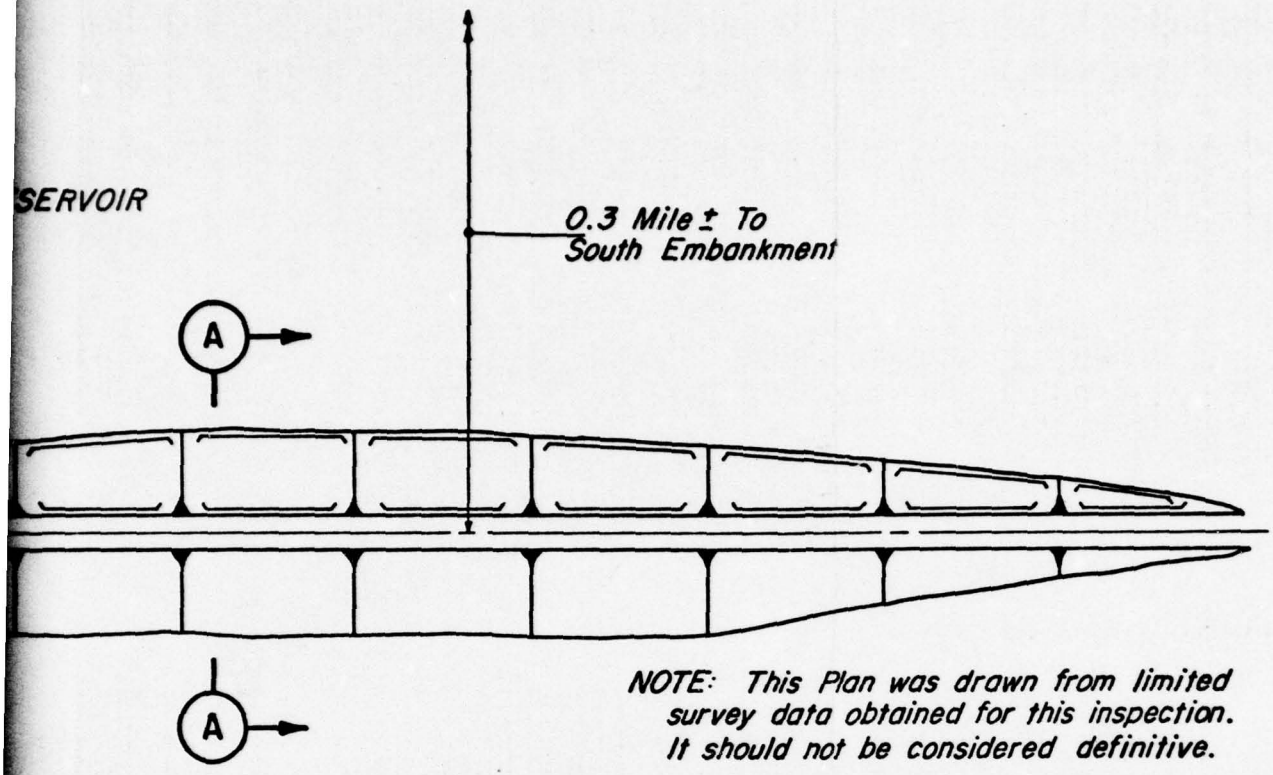


APPROXIMATE CANAL SECTION
(LOOKING DOWNSTREAM)
SCALE: 1" = 5'



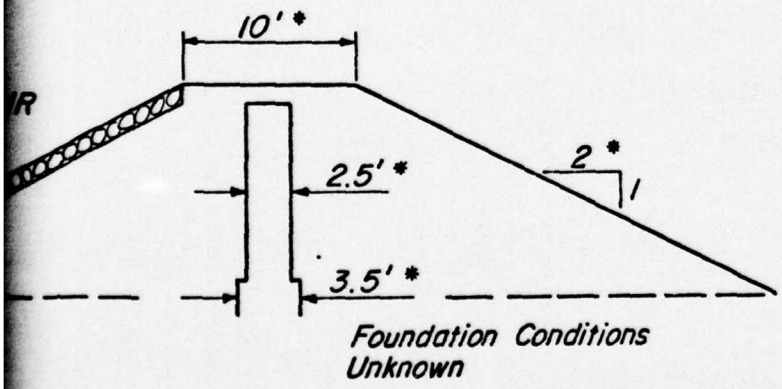
* Information obtained from Pennsylvania Water Supply Commission Report.

SECTION
SCALE: 1" = 10



NOTE: This Plan was drawn from limited survey data obtained for this inspection. It should not be considered definitive.

PLAN
SCALE: 1" = 50'



tained from Pennsylvania
Commission Report.

SECTION A
SCALE: 1" = 10'

2

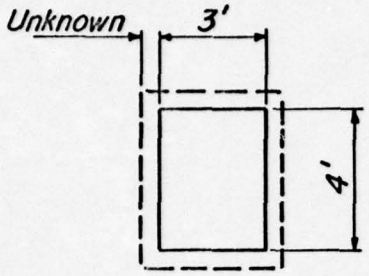
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

CAMPBELLS LEDGE DAM

PENNSYLVANIA GAS AND WATER COMPANY

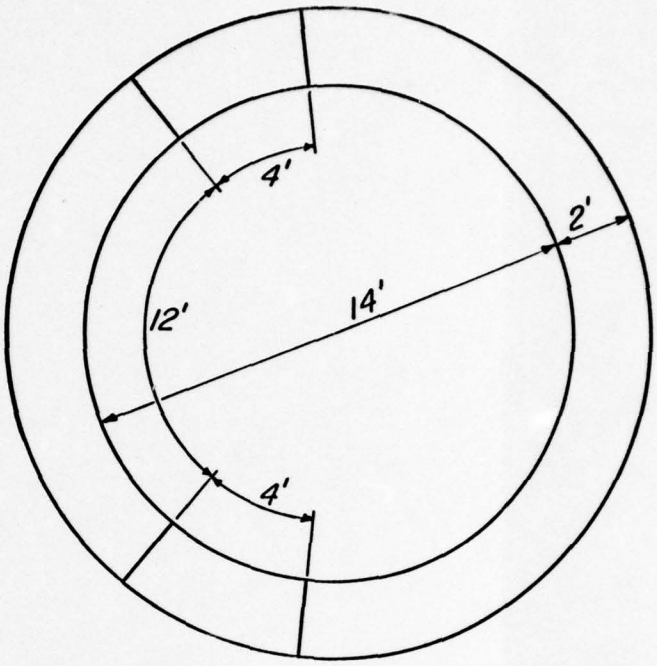
NORTH EMBANKMENT
PLAN AND SECTION

JANUARY 1979 PLATE 3



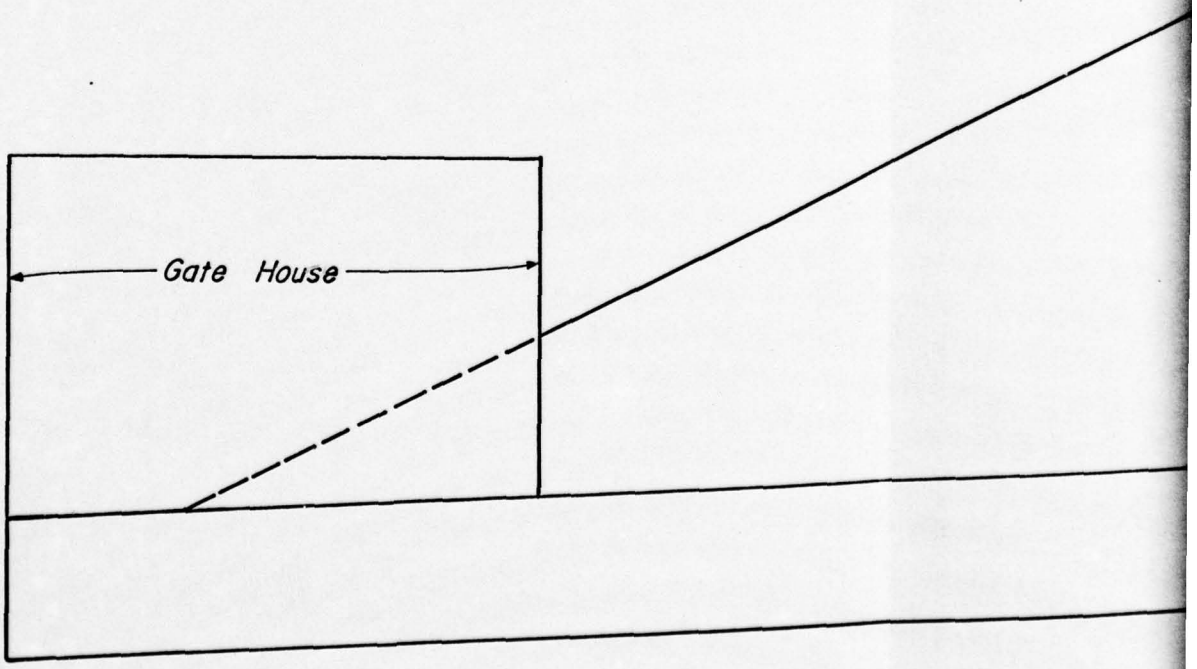
CONDUIT SECTION

SCALE: 1" = 5'

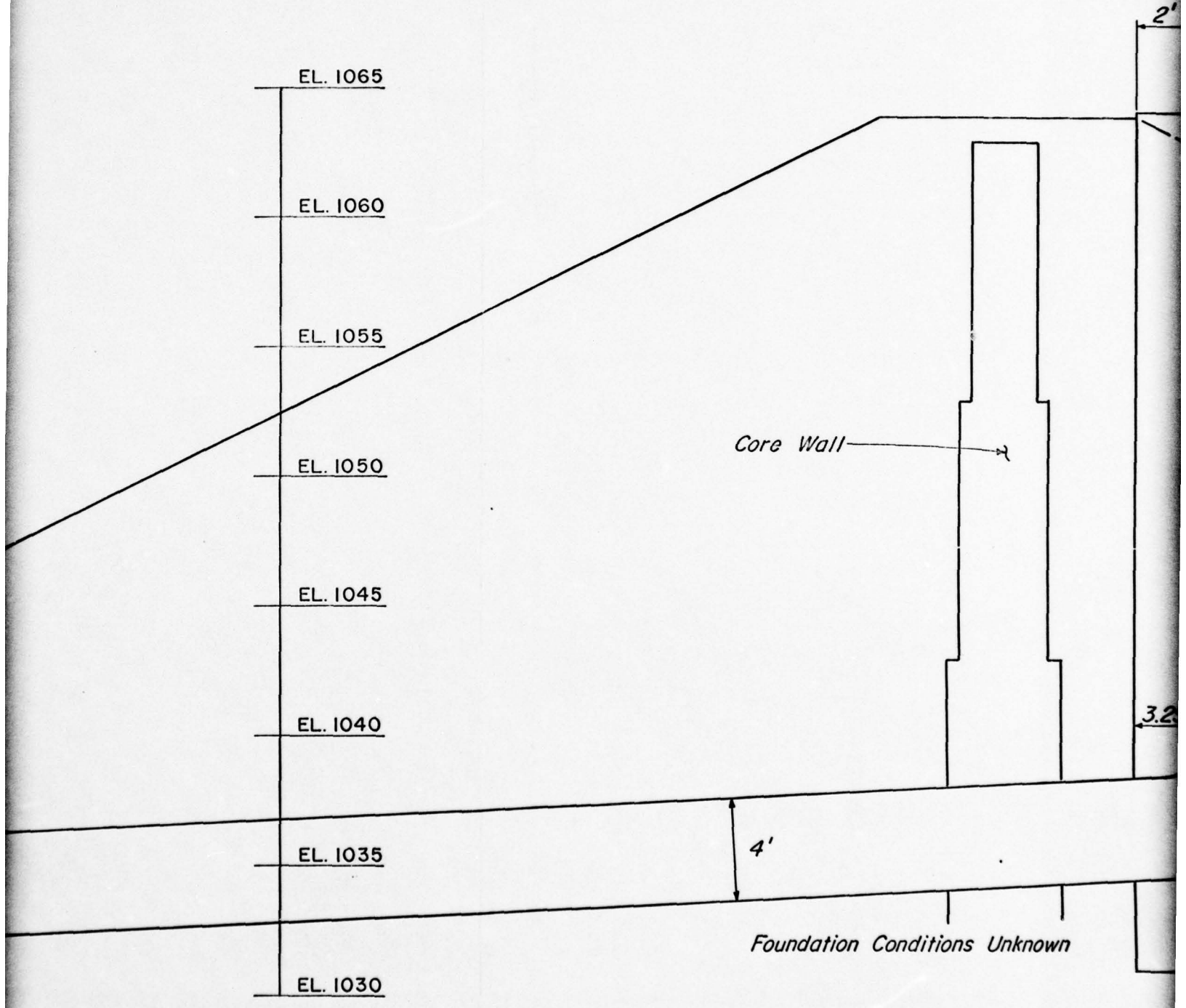


PLAN

SCALE: 1" = 5'



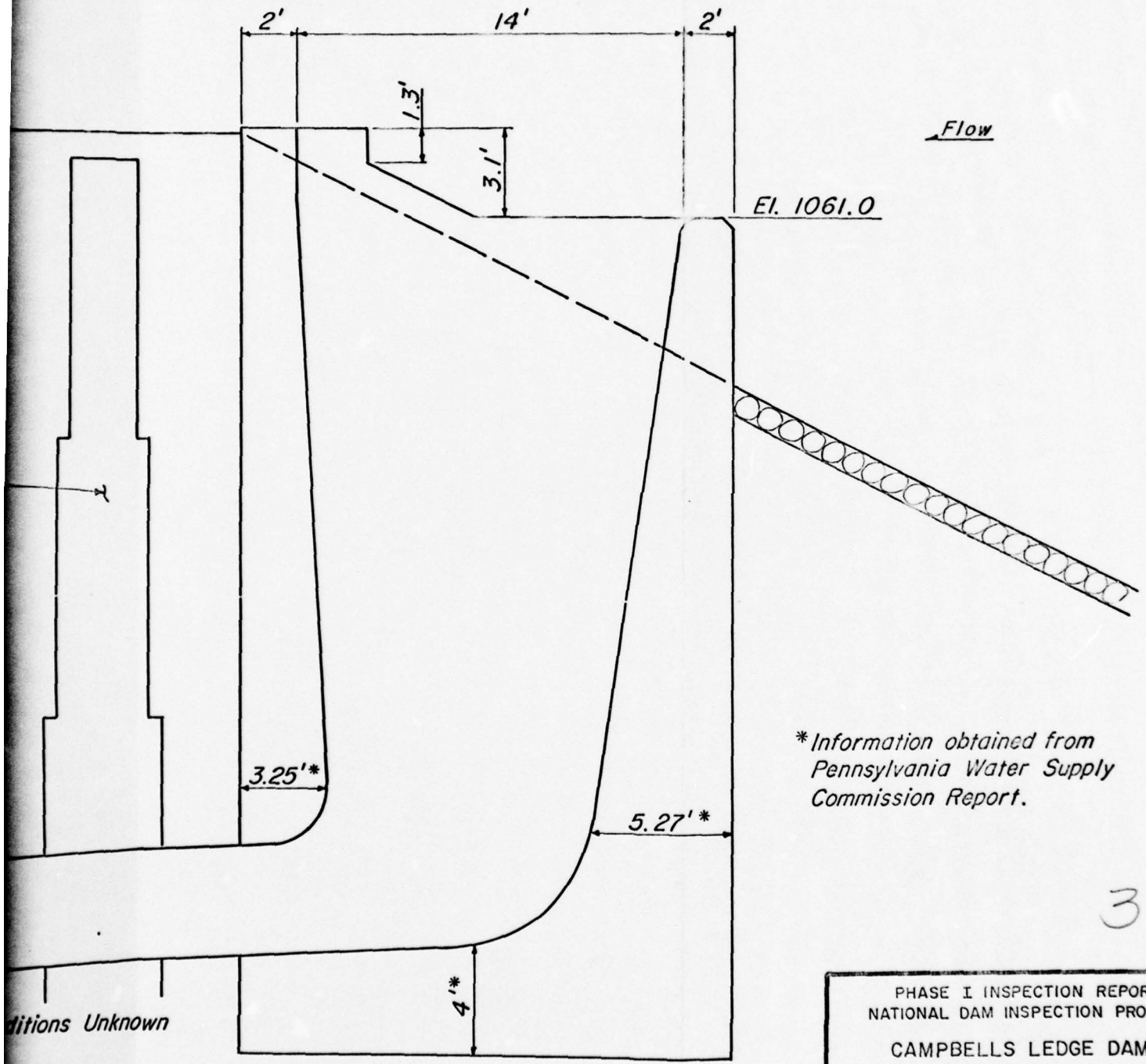
NOTE: This Plan was drawn from limited survey data obtained for this inspection. It should not be considered definitive.



PROFILE

SCALE: 1" = 5'

2



*Information obtained from Pennsylvania Water Supply Commission Report.

3

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

CAMPBELLS LEDGE DAM

PENNSYLVANIA GAS AND WATER COMPANY

SPILLWAY DETAILS

JANUARY 1979 PLATE 4

SUSQUEHANNA RIVER BASIN

CAMPBELLS LEDGE CREEK, LUZERNE COUNTY

PENNSYLVANIA

CAMPBELLS LEDGE DAM

NDI ID No. PA-00649
DER ID No. 40-19

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JANUARY 1979

APPENDIX A

CHECKLIST - ENGINEERING DATA

CHECKLIST

ENGINEERING DATA

DESIGN, CONSTRUCTION, AND OPERATION
PHASE I

NAME OF DAM: Campbells Ledge

NDS ID NO.: PA-00649 DER ID NO.: 40-19

Sheet 1 of 4

ITEM	REMARKS
AS-BUILT DRAWINGS	NONE IN RECORDS
REGIONAL VICINITY MAP	SEE PLATE 1
CONSTRUCTION HISTORY	BUILT 1905-1906
TYPICAL SECTIONS OF DAM	NONE IN RECORDS
OUTLETS: Plan Details Constraints Discharge Ratings	NO INFORMATION

A-1

ENGINEERING DATA

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	NONE
DESIGN REPORTS	1914 PENNSYLVANIA WATER SUPPLY COMMISSION REPORT
GEOLOGY REPORTS	1914 PENNSYLVANIA WATER SUPPLY COMMISSION REPORT
DESIGN COMPUTATIONS: Hydrology and Hydraulics Dam Stability Seepage Studies	NONE
MATERIALS INVESTIGATIONS: Boring Records Laboratory Field	NONE
POSTCONSTRUCTION SURVEYS OF DAM	NONE

ENGINEERING DATA

ITEM	REMARKS
BORROW SOURCES	NOT AVAILABLE
MONITORING SYSTEMS	NONE
MODIFICATIONS	NONE EXCEPT TO WATER SUPPLY LINE
HIGH POOL RECORDS	NONE
POSTCONSTRUCTION ENGINEERING STUDIES AND REPORTS	1914 WATER SUPPLY COMMISSION REPORT
PRIOR ACCIDENTS OR FAILURE OF DAM: Description Reports	NONE

ENGINEERING DATA

ITEM	REMARKS
MAINTENANCE AND OPERATION RECORDS	NONE
SPILLWAY: Plan Sections Details	NONE
OPERATING EQUIPMENT: Plans Details	NONE
PREVIOUS INSPECTIONS Dates Deficiencies	1919 - Top of dam settled. 1920 - Embankment raised but ungraded 1921 - Top of Embankment not graded. 1922 - Top of Embankment not graded. Downstream toe of north embankment is swampy. Concrete in stilling basin is slightly disintegrated. 1924 - No defects. 1927 - Slight seepage at outlet works. Concrete at outlet works disintegrating.
(CONTINUED)	Riprap uneven. Some seepage below embankment. 1929 - Slight seepage at north embankment. 1930 - No defects.

4-4

ENGINEERING DATA

ITEM	REMARKS
PREVIOUS INSPECTIONS (CONTINUED)	1933 - RIPRAP ON UPSTREAM FACE APPEARS TO HAVE SETTLED. BRUSH ON DOWNSTREAM FACE SEEPAGE AT "INSPECTION TUNNEL DRAIN" AND SWAMPY AREA AT TOE NEAR LEFT END. NORTH EMBANKMENT - NO DEFECTS
	1934 - SEEPAGE FROM SPILLWAY CONDUIT. SWAMPY AREA 100 FEET FROM LEFT END.
	1941 - TOP OF MAIN EMBANKMENT UNEVEN. RIPRAP MISSING NEAR SPILLWAY SEEPAGE THROUGH SPILLWAY JOINTS.
	SEEPAGE BETWEEN OUTLET WORKS PIPES. TOE OF MAIN EMBANKMENT WET AND SWAMPY FOR 150 NEAR LEFT END. TOE OF AUXILIARY DAM IS WET AND SWAMPY FOR 100 FEET
	NEAR CENTER. SURFACE DISINTEGRATION OF CONCRETE IN SPILLWAY THROAT AND AT STILLING BASIN. LARGE TREES AT TOE OF MAIN EMBANKMENT.
	1943 - AS ABOVE, EXCEPT STILLING BASIN
	CONCRETE SLAB ENTIRELY DISINTEGRATED AND A LARGE CRACK IN EACH STILLING BASIN WALL.
	1965 - NO DEFECTS

SUSQUEHANNA RIVER BASIN

CAMPBELLS LEDGE CREEK, LUZERNE COUNTY

PENNSYLVANIA

CAMPBELLS LEDGE DAM

NDI ID No. PA-00649
DER ID No. 40-19

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JANUARY 1979

APPENDIX B

CHECKLIST - VISUAL INSPECTION

CHECKLIST

VISUAL INSPECTION

PHASE I

Name of Dam: CAMPBELLS LEDGE **County:** LUZERNE **State:** PENNSYLVANIA

NDS ID No.: PA-00649 **DER ID No.:** 40-19

Type of Dam: EARTHFILL WITH CONCRETE COREWALL **Hazard Category:** SIGNIFICANT

Date(s) Inspection: 9 NOV. & 10 NOV. 1978 **Weather:** CLEAR **Temperature:** 60°F

SOIL CONDITIONS: MOIST

Pool Elevation at Time of Inspection: SEE BELOW msl/**Tailwater at Time of Inspection:** NONE - NO DISCHARGE msl

POOL 9 NOV 4:35 PM 1056.52, POOL 10 NOV 9:15 AM 1057.12

Inspection Personnel:

J. CROUSE (GFCC)

G. SMITH (GFCC)

E. SHARJOLIS (PGW)

A. WHITMAN (GFCC) Recorder

4-3

SOUTH EMBANKMENT

Sheet 1 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	TIRE RUTS	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	NONE	
SLOUGHING OR EROSION: Embankment Slopes Abutment Slopes	NONE	
CREST ALIGNMENT: Vertical Horizontal	SEE SURVEY DATA FOLLOWING INSPECTION FORMS	
RIPRAP FAILURES	MINOR BULGING, ENTIRE UPSTREAM FACE ABOUT 4 FEET BELOW TOP.	

SOUTH EMBANKMENT

Sheet 2 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT WITH: Abutment Spillway Other Features	NONE	
ANY NOTICEABLE SEEPAGE	NONE	
STAFF GAGE AND RECORDER	NONE	
DRAINS	NONE	
BRUSH	MATURE TREES AT TOE TO RIGHT OF OUTLET WORKS.	SPORADIC 1" DIAMETER BRUSH ON EMBANKMENT EXCEPT AT ABUTMENTS, WHERE 1" - 2" BRUSH IS THICKER.

NORTH EMBANKMENT

Sheet 1 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	NONE	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	NONE	
SLOUGHING OR EROSION: Embankment Slopes Abutment Slopes	MINOR SURFACE EROSION MATERIAL AT TOP OF DAM ONTO RIPRAP.	INSUFFICIENT QUANTITY TO BE OF SIGNIFICANCE.
CREST ALIGNMENT: Vertical Horizontal	SEE SURVEY DATA AT END OF INSPECTION FORMS	SOIL: GRAVELLY SILT
RIPRAP FAILURES	NONE	

B I I

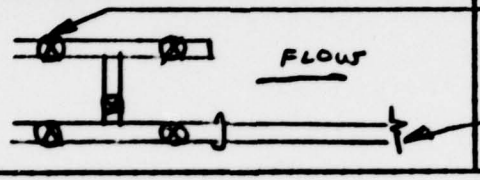
NORTH EMBANKMENT

Sheet 2 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT WITH: Abutment Spillway Other Features	NONE	
ANY NOTICEABLE SEEPAGE	WET AREA 65' LONG X 15' WIDE WOODED AT STA 3+00 GFCC SURVEY.	
STAFF GAGE AND RECORDER	NONE	
DRAINS	NONE	
BRUSH	SPORADIC	CUT BRUSH AT DOWNSTREAM TOE

OUTLET WORKS

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	2-16" DIA. CIP	
INTAKE STRUCTURE	SUBMERGED	OBSERVED UNDERWATER RIGHT OF SPILLWAY. 
OUTLET STRUCTURE	SEE SPILLWAY	
OUTLET CHANNEL	SEE SPILLWAY	
EMERGENCY GATE		BROKEN, PARTS DUE TO BE DELIVERED SPRING 1979 PACKINGS LEAK. WATER SUPPLY LINE

UNGATED SPILLWAY

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	RECENTLY REPAIRED MAJOR SPALLING FROM 6' BELOW CREST. IRON FENCE AROUND CREST.	SEE PLATE 4 SEEPAGE THROUGH DETERIORATED CONCRETE.
APPROACH CHANNEL	RESERVOIR	
DISCHARGE CHANNEL	SEE NEXT SHEET	
BRIDGE AND PIERS	NONE	

~~OUTLET WORKS~~ CONDUIT FOR SPILLWAY

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	SEVERE SCOUR ALONG BOTTOM OF CONDUIT. REBAR EXPOSED, SEVERLY RUSTING, AND DETERIORATED AT MANY SPOTS ON ROOF.	
INTAKE STRUCTURE	SEVERE SPALLING AT ENTRANCE	
OUTLET STRUCTURE	SLAB COMPLETELY SCOURED. LEFT WALL: SHRINKAGE CRACK 15' DOWNSTREAM, SHRINKAGE CRACK WITH SPALL AT CURVE	RIGHT WALL: CRACK 15' DOWNSTREAM, UPSTREAM END TILTED TOWARD STILLING BASIN
OUTLET CHANNEL	SEE DOWNSTREAM CHANNEL	TOTAL SEEPAGE OUT ≈ 0.5 gpm APPEARED TO BE GREATER IN SPILLWAY THROAT
EMERGENCY GATE	NONE	

INSTRUMENTATION

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	NONE	
OBSERVATION WELLS	NONE	
WEIRS	NONE	
PIEZOMETERS	NONE	
OTHER	NONE	

RESERVOIR AND WATERSHED

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	STEEP	
SEDIMENTATION	NO PROBLEM FOR CAPACITY. SEDIMENT CAN FOUL WATER SUPPLY INTAKE	DATA FROM OWNER
WATERSHED DESCRIPTION	OUTCROP RELATIVELY STEEP SLOPES WOODED CONTROLLED BY PGW.	

W-10

DOWNSTREAM CHANNEL

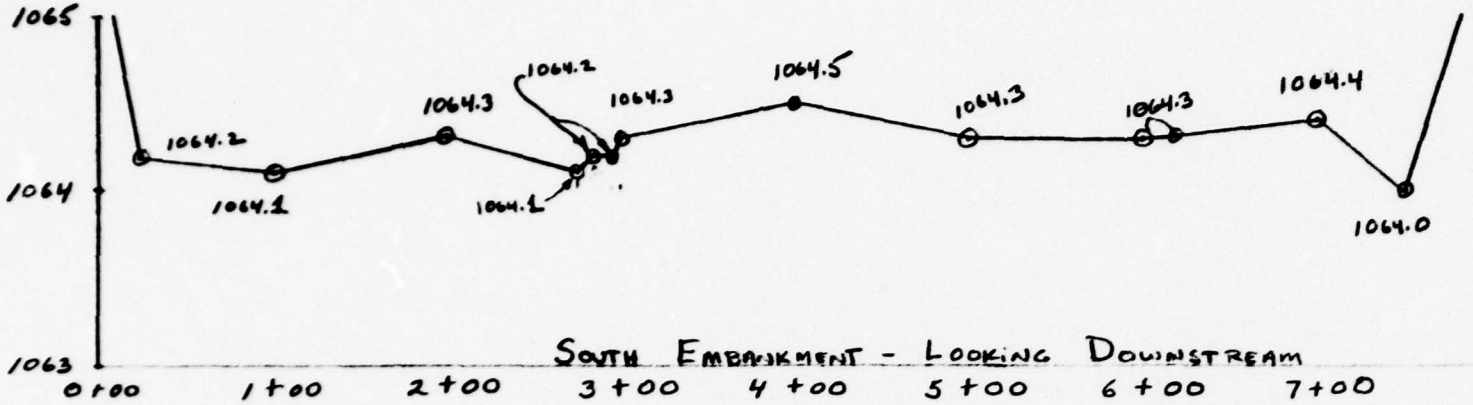
Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION: Obstructions Debris Other	NONE	
SLOPES	STEEP	
APPROXIMATE NUMBER OF HOMES AND POPULATION	LEADS TO ABANDONED STRIP MINE.	

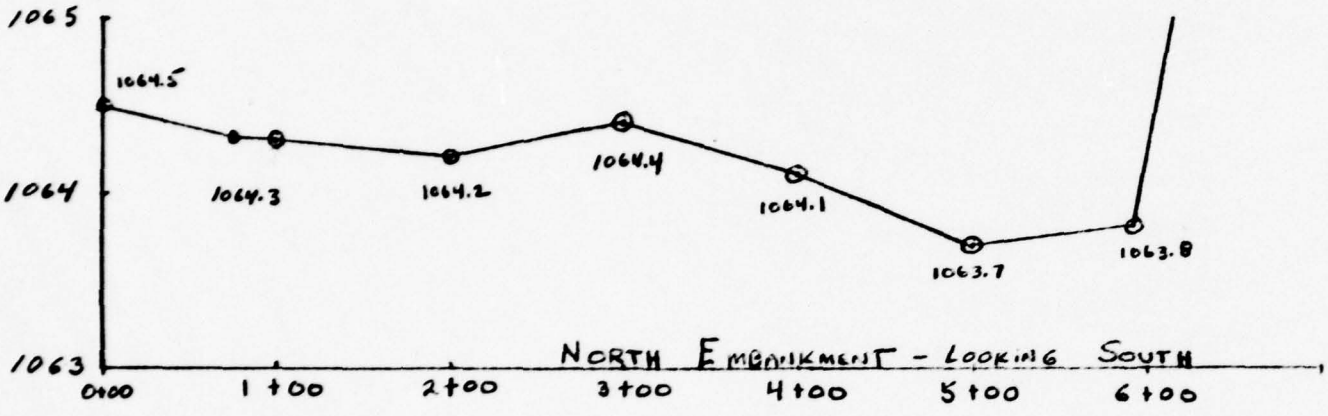
B-11

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Campbells Ledge FILE NO.
SHEET NO. OF SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE



SOUTH EMBANKMENT - LOOKING DOWNSTREAM



NORTH EMBANKMENT - LOOKING SOUTH

B-12

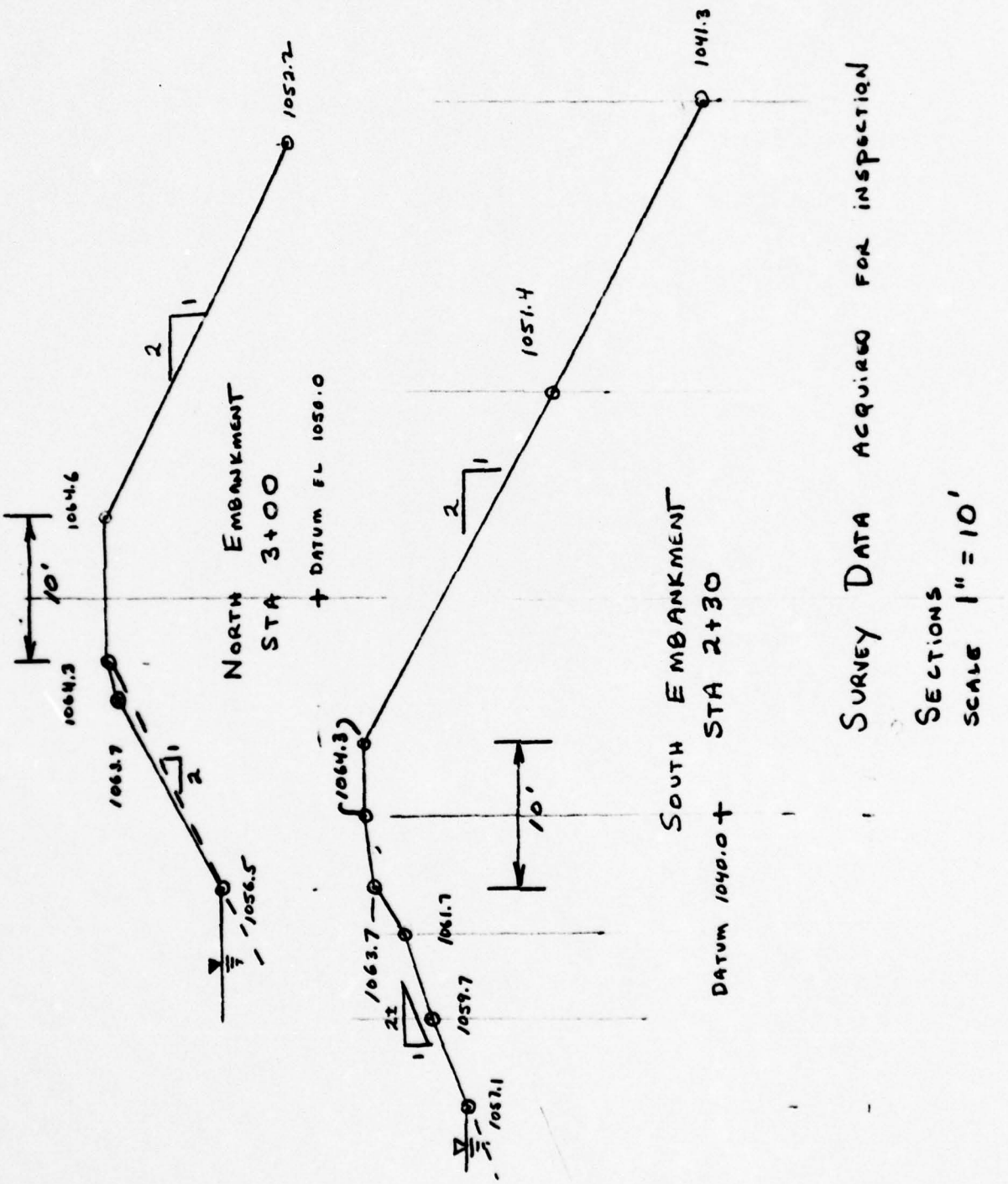
SURVEY DATA ACQUIRED FOR INSPECTION

PROFILES

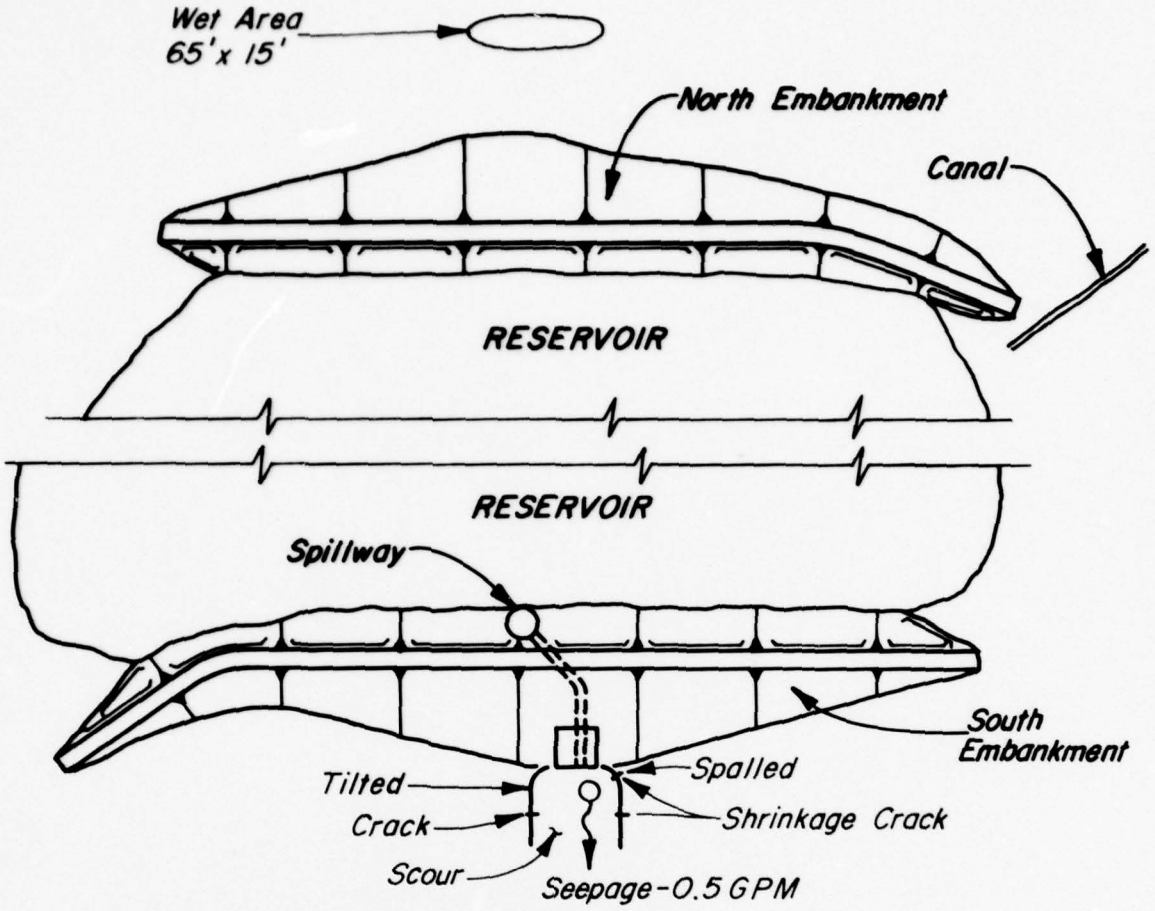
SCALE HORIZONTAL: 1" = 100', VERTICAL: 1" = 1'

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

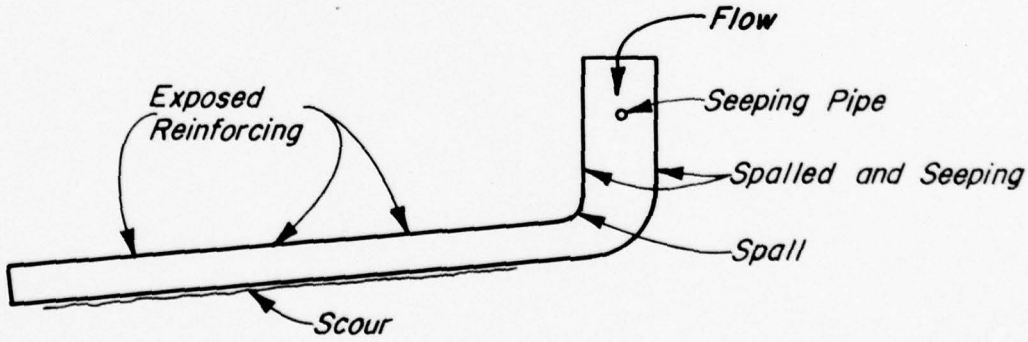
SUBJECT Campbells Ledge FILE NO.
SHEET NO. OF SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE



SP 11660A



EMBANKMENTS - PLAN
NOT TO SCALE



SPILLWAY PROFILE
NOT TO SCALE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

CAMPBELLS LEDGE DAM

PENNSYLVANIA GAS AND WATER COMPANY

RESULTS OF VISUAL INSPECTION

JANUARY 1979 PLATE B-1

SUSQUEHANNA RIVER BASIN

CAMPBELLS LEDGE CREEK, LUZERNE COUNTY

PENNSYLVANIA

CAMPBELLS LEDGE DAM

NDI ID No. PA-00649
DER ID No. 40-19

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JANUARY 1979

APPENDIX C

HYDROLOGY AND HYDRAULICS

APPENDIX C

HYDROLOGY AND HYDRAULICS

In the recommended Guidelines for Safety Inspection of Dams, the Department of the Army, Office of the Chief of Engineers (OCE), established criteria for rating the capacity of spillways. The recommended Spillway Design Flood (SDF) for the size (small, intermediate, or large) and hazard potential (low, significant, or high) classification of a dam is selected in accordance with the criteria. The SDF for those dams in the high hazard category varies between one-half of the Probable Maximum Flood (PMF) and the PMF. If the dam and spillway are not capable of passing the SDF without overtopping failure, the spillway capacity is rated as inadequate. If the dam and spillway are capable of passing one-half of the PMF without overtopping failure, or if the dam is not in the high hazard category, the spillway capacity is not rated as seriously inadequate. A spillway capacity is rated as seriously inadequate if all of the following conditions exist:

(a) There is a high hazard to loss of life from large flows downstream of the dam.

(b) Dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure.

(c) The dam and spillway are not capable of passing one-half of the PMF without overtopping failure.

1967.2

APPENDIX C

SUSQUEHANNA River Basin

Name of Stream: CAMPBELLS LEDGE CREEK

Name of Dam: CAMPBELLS LEDGE

NDI ID No.: PA-00649

DER ID No.: 40-19

Latitude: N 41° 21' 45" Longitude: W 75° 47'25"

Top of Dam (low spot) Elevation: 1064.0

Streambed Elevation: 1030.8 Height of Dam: 33 ft

Reservoir Storage at Top of Dam Elevation: 281 acre-ft

Size Category: SMALL

Hazard Category: SIGNIFICANT (see Section 5)

Spillway Design Flood: 100 YEAR TO ½ PMF, USE ½ PMF

UPSTREAM DAMS

Name	Distance from Dam (miles)	Height (ft)	Storage at top of Dam Elevation (acre-ft)	Remarks
FALLING SPRINGS	0.3	7	LESS THAN	DIVERTS OUTFLOWS
DIVERSION WORKS			0.5 MG	FROM FALLING
DER ID				SPRINGS DAM
(40-106)				DER MAPPING IN ERROR

DOWNSTREAM DAMS

CAMPBELLS	.28	22	3 (APPROX.)	IGNORED IN
LEDGE				COMPUTATIONS
INTAKE DAM				(CONSIDERED
DER ID (40-30)				ABANDONED BY OWNER)

SUSQUEHANNA River Basin

Name of Stream: CAMPBELLS LEDGE CREEK

Name of Dam: CAMPBELLS LEDGE

NDI ID No.: PA-00649

DER ID No.: 40-19

Latitude: N 41° 22' Longitude: W 75° 47'

DETERMINATION OF PMF RAINFALL

For Area A

which consists of Subareas A1 of .09 sq. mile

A2 .23

Total Drainage Area 0.32 sq. mile

PMF Rainfall Index = 22.15 in., 24 hr., 200 sq. mile

	Hydromet. 40 (Susquehanna Basin)	Hydromet. 33 (Other Basins)
Zone	N/A	N/A
Geographic Adjustment Factor	97%	1.0
Revised Index Rainfall	21.5	N/A

RAINFALL DISTRIBUTION (percent)

Time	Percent
6 hours	118
12 hours	127
24 hours	136
48 hours	142
72 hours	145
96 hours	N/A

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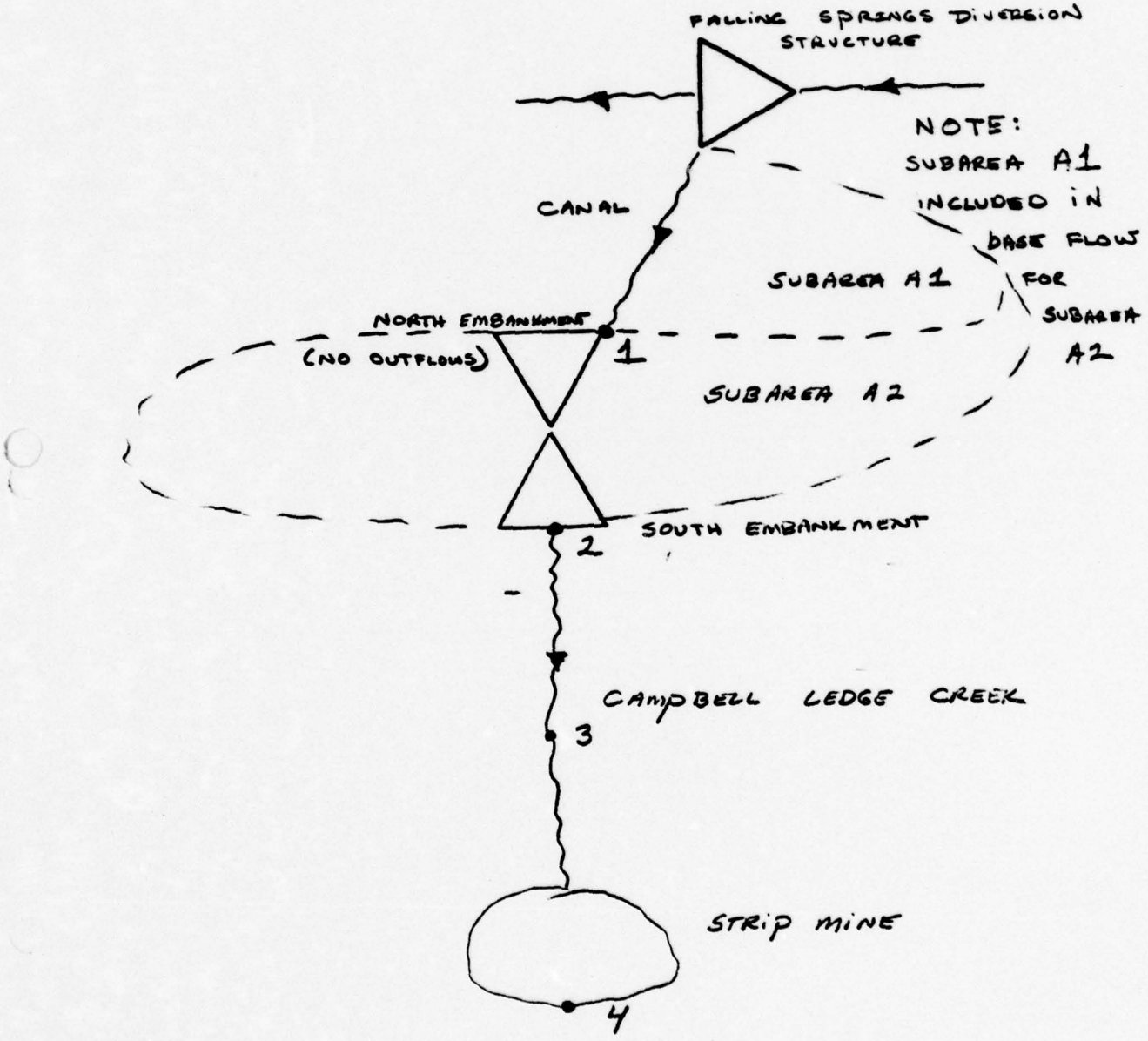
HARRISBURG, PA.

SUBJECT Campbells Ledge FILE NO.
SHEET NO. OF SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE

SKETCH OF SYSTEM



SP 11060A

Data for Dam at Outlet of Subarea A-1
(see Sketch on Sheet C-4)

~~Name of Dam~~: DELIVERY OF CANAL Sheet 1 of 3

Height: N/A (existing)

Spillway Data:	Existing Conditions	Design Conditions
Top of Dam Elevation	N/A	
Spillway Crest Elevation		
Spillway Head Available (ft)		
Type Spillway	CANAL - NORMAL DEPTH COMPUTATIONS	
"C" Value - Spillway	SEE NEXT SHEET	
Crest Length - Spillway (ft)		
Spillway Peak Discharge (cfs)		
Auxiliary Spillway Crest Elevation		
Auxiliary Spillway Head Available (ft)		
Type Auxiliary Spillway	NONE	
"C" Value - Auxiliary Spillway		
Crest Length - Auxiliary Spillway (ft)		
Auxiliary Spillway Peak Discharge (cfs)		
Combined Spillway Discharge (cfs)		

Spillway Rating Curve:

CANAL Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)
1061.0	0	N/A	0
1062.0	32	-	32
1063.0	78	-	78
1064.0	132	-	132
1065.0	210	-	210
1080.0	211	-	211

SUSQUEHANNA River Basin River Basin

Name of Stream: CAMPBELLS LEDGE CREEK

Name of Dam: CAMPBELLS LEDGE

NDI ID No.: PA-00649

DER ID No.: 40-19

Latitude: N 41° 21' 45" Longitude: W 75° 47' 25"

Drainage Area: 0.09 sq. mile

Data for Subarea: A-1 (see Sketch on Sheet C-4)

~~Name of Dam at~~ Outlet of Subarea: CANAL DELIVERY

Drainage Area of Subarea: 0.09 sq. mile

Subarea Characteristics:

Assumed Losses: 1.0-inch initial abstraction + 0.05 in/hr

The following are measured from outlet of subarea to the point noted:

L = Length of Main Watercourse extended to the divide = 0.66 mile

L_{CA} = Length of Main Watercourse to the centroid = 0.166 mile

From NAB Data: AREA 11 PLATE E

Cp = 0.62

C_T = 1.50

$Tp = C_T \times (L \times L_{CA})^{0.3}$ = .77 (hrs)

Flow at Start of Storm = ~~1.5 cfs/sq. mile x Subarea D.A~~ = 210 cfs
(ASSUMED [illegible] FROM FALLING SPRINGS DAM)

Computer Data:

QRCSN = -0.05 (5% of peak flow)

RTIOR = 2.0

Remarks: _____

Data for Dam at Outlet of Subarea A1

~~Name of Dam~~: CANAL DELIVERY Sheet 3 of 3

Storage Data:

Elevation	Area (acres)	Storage million gals	Storage acre-ft	Remarks
1061.0 ~~= ELEVC~~*	0	0	0	
1062.0 ~~= ELEVI~~	.21 ~~= AI~~		.07 ~~= SI~~	
1063.0	.31		.33	
1064.0	.41		.69	
1065.0	.52		1.16	
[illegible]	[illegible]			[illegible]
**				

~~* ELEVC = ELEVI + (3S$_I$/A$_I$)~~

~~** Planimetered contour at least 10 feet above top of dam~~

Reservoir Area at Top of Dam is N/A percent of watershed.

Remarks: _____

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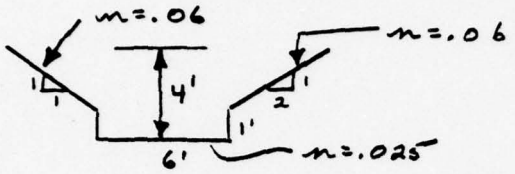
SUBJECT Campbell Ledge FILE NO.
SHEET NO. 2 OF 3 SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE

Delivery of Canal



$$\text{Area} = \frac{3^2}{2} + \frac{3^2}{2} \times 2 + 4 \times 6 = 37.5 \text{ FT}^2$$

Wetted Perimeter =

$3\sqrt{2} + 8 + \sqrt{5} \times 3$

$4.24 + 8 + 6.71 = 18.95 \text{ FT}$

$R = A/P = 37.5/18.95 = 1.979 \text{ FT}$

$R^{2/3} = 1.5763$

Ref: WES, Vicksburg HDC 631-4

$$n = \left(\frac{\Sigma n_i^{3/2} P_i}{\Sigma P} \right)^{2/3} = .047$$

$$\frac{Q}{S^{1/2}} = \frac{1.486}{.047} (1.5763)(37.5) = 1872.38$$

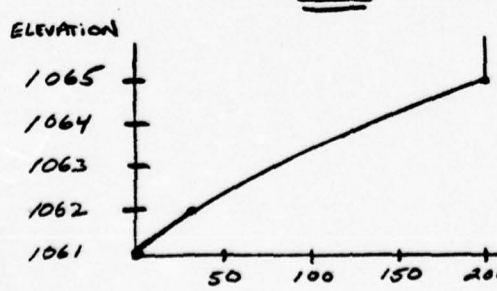
$L = 1500'$

$D = 19'$ $\quad S = 17/1500 = .01133$

$\sqrt{S} = .1064$

$Q = 1872.38 \times .1064 = 199.3 \text{ cfs} \approx \underline{200 \text{ cfs}}$

At $\underline{d = 1'}$ $A = 6'$ $P = 8'$ $\underline{Q = 31.0}$



C ELEVATIONS
ARBITRARY
1061 = BOTTOM CANAL

SP 11860A

Data for Dam at Outlet of Subarea A-2
(see Sketch on Sheet C-4)

Name of Dam: CAMPBELLS LEDGE Sheet 1 of 3

Height: 33 FT. (existing)

Spillway Data:	Existing Conditions	Design Conditions
Top of Dam Elevation	1063.7	1064.0
Spillway Crest Elevation	1061.0	1061.0
Spillway Head Available (ft)	2.7	3.0
Type Spillway	MORNING GLORY	
"C" Value - Spillway	3.4	3.4
Crest Length - Spillway (ft)	VARIES - SEE	SHEETS
Spillway Peak Discharge (cfs)	C-10 TO C-13	
Auxiliary Spillway Crest Elevation	NONE	NONE
Auxiliary Spillway Head Available (ft)	-	-
Type Auxiliary Spillway	-	-
"C" Value - Auxiliary Spillway	-	-
Crest Length - Auxiliary Spillway (ft)	-	-
Auxiliary Spillway Peak Discharge (cfs)	-	-
Combined Spillway Discharge (cfs)	354?355	360

Spillway Rating Curve:

Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)
	SEE SHEET C-13		

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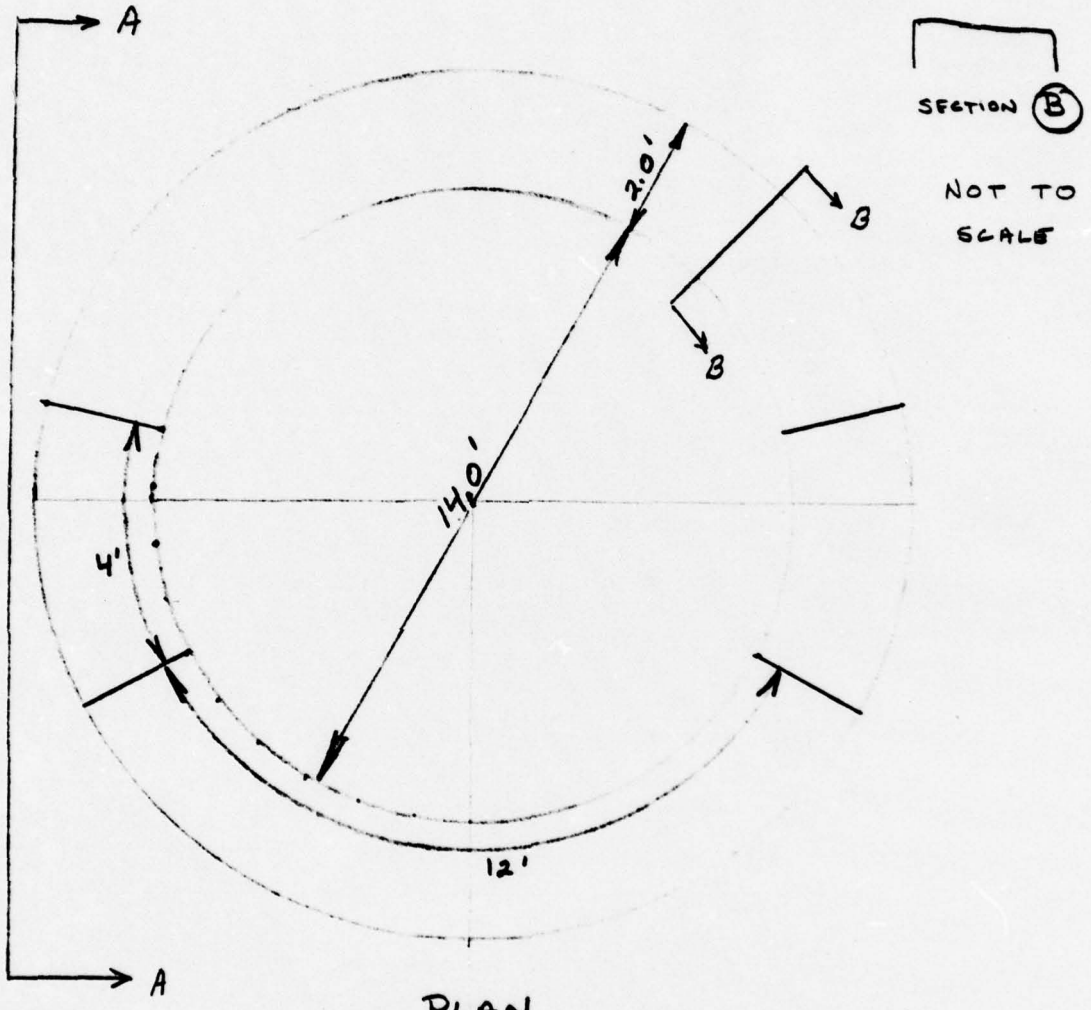
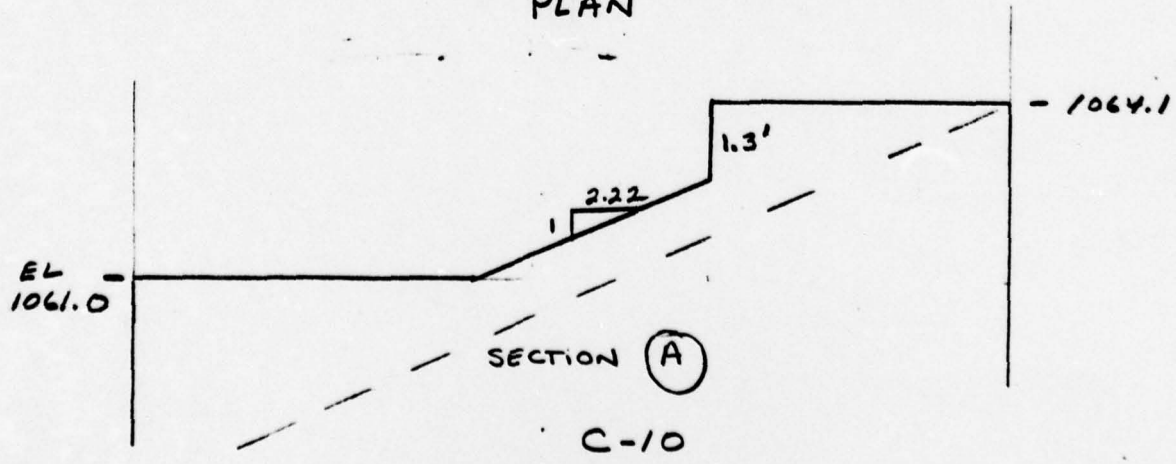
SUBJECT Camp Bell Ledge Spillway FILE NO.
SHEET NO. 1A OF 3 SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE



SECTION (B)

NOT TO SCALE

PLAN



SECTION (A)

C-10

SP 11660A

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SUBJECT Campbell Ledge FILE NO.
SHEET NO. 13 OF 3 SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE

Spillway Rating

$D = 14' + 2 \times 2' = 18'$

$C = \pi D = 56.54'$

83°

INTERNAL $\angle \alpha_2 = \frac{12}{14\pi} \times 360$

$= 98.22$

$L' = \frac{98.22}{360} \times 18\pi$

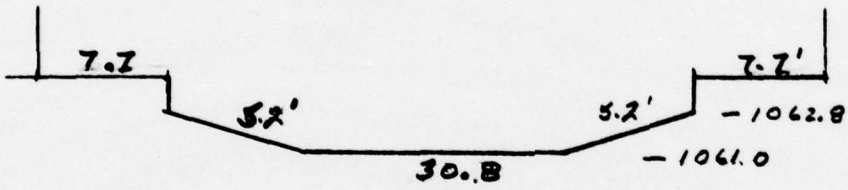
$= 15.42'$

INTERNAL ANGLE α_1

$360 - \frac{12+4+4}{14\times\pi} \times 360 = 196.30°$

EFFECTIVE LENGTH $= \frac{196.3}{360} \times 56.54$

$= 30.83$



W.S. ELEV	T (FT)	A FT²	$Q' = \sqrt{\frac{A^3 g}{T}}$ CFS	$Q = \frac{3.4}{3.1} Q'$ CFS	hv (FT)	POOL	h'	THROAT ELEV
1061.0	0	0	0	0	0	1061.0	0	1035.0
1062.0	36.8	33.8	184	202	.6	1062.6	9.18	1044
1062.8	41.2	64.8	461	506	.9	1063.7	57.6	1092.6

NOTE CHANGE IN CONTROL

SEE NEXT SHEET

SP 11860A

35'

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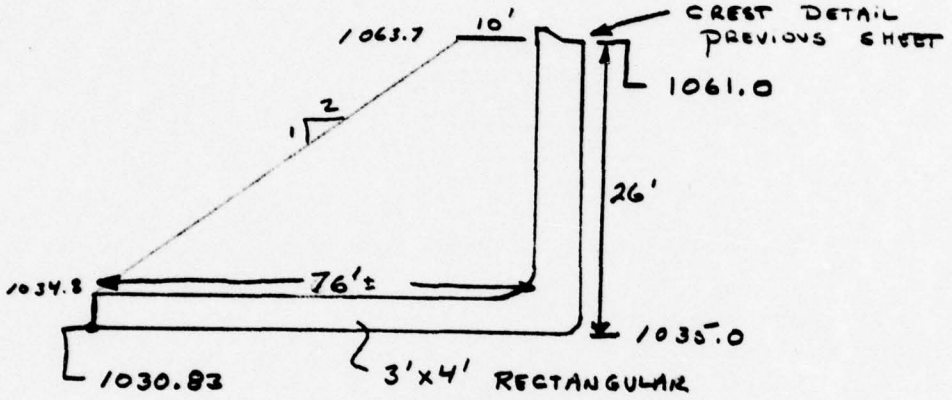
SUBJECT Campbell Ledge Spillway FILE NO.
SHEET NO. 16 OF 3 SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE



AREA = 12 FT²

P = 14 FT

A/P = R = .857

$$V = \frac{1.486}{n} R^{2/3} \cdot S^{1/2}$$

$$\frac{V^2}{2g} \frac{2g}{(1.486)^2} \frac{n^2 L}{R^{4/3}} = h_L$$

$$K_{FRICTION} = \frac{29.1 n^2 L}{R^{4/3}}$$

CONCRETE IS ROUGH - FORMED

USE $n = .017$ (CHOW)

$$K_f = \frac{29.1 (.017)^2 \times 76}{(.857)^{4/3}} = 0.785$$

$K_{EXIT} = 1.00$

$K_{ENTRANCE} = 0.3$ (ROUNDED ENTRANCE)

$\Sigma K = 2.085$

$$Q = 12 \sqrt{\frac{2g}{2.085}} \sqrt{H} = 66.668 \sqrt{H}$$

$$H = \frac{Q^2}{66.668}$$

SP 11868A

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Campbell Ledge FILE NO.
SHEET NO. 1D OF 3 SHEETS
FOR
COMPUTED BY DATE CHECKED BY DATE

FOR pipe CONTROL
ADD LOSSES DOWN THROAT

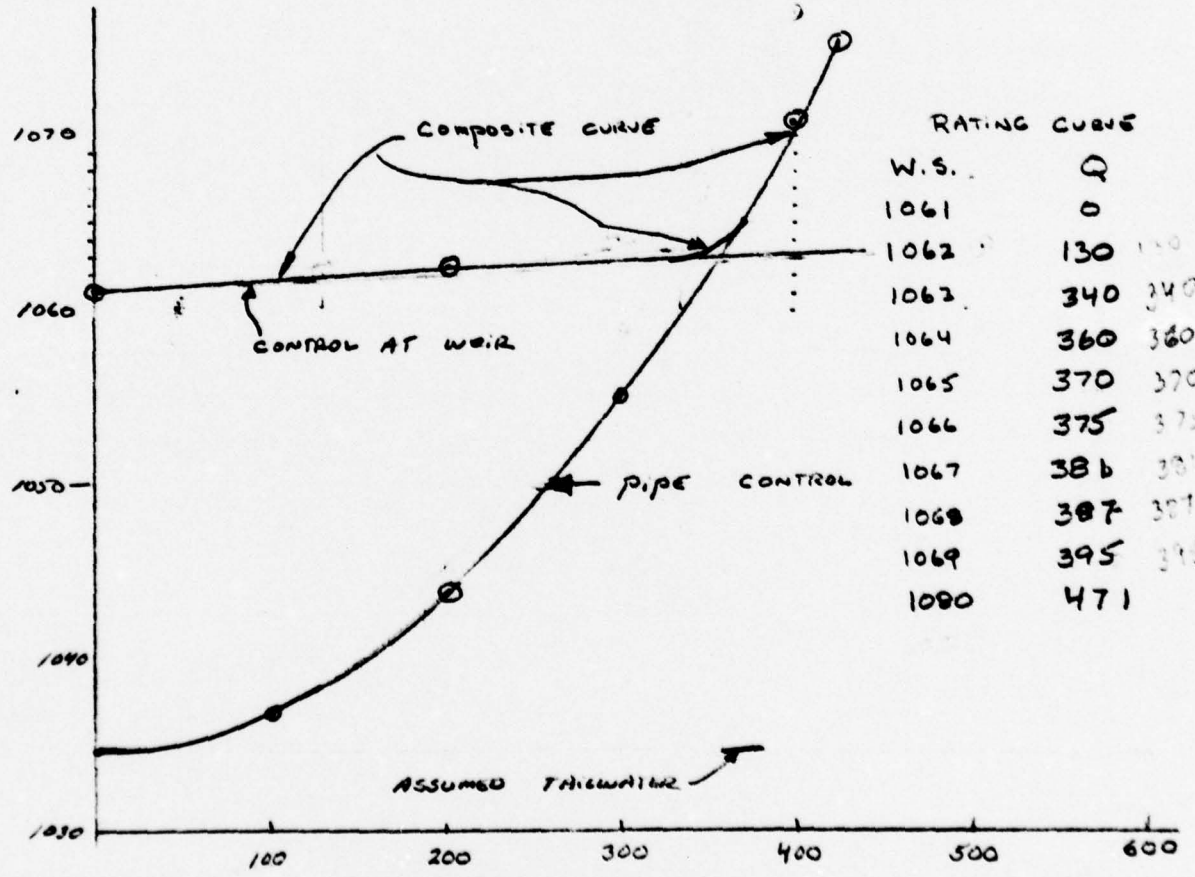
$K_e = \frac{29.1\, n^2 L}{R^{4/3}}$ $R = D/4 = 14/4 = 3.5'$

$= \frac{29.1\,(.015)^2 \times 26}{3.5^{4/3}} = .032$

REFERENCE TO OUTLET

$.032 \left(\frac{\pi 14^2/4}{12} \right)^2 = .001$ (NEGL)

ORIGINAL RATING HOLDS



RATING CURVE

W.S.	Q	
1061	0	
1062	130	130
1063	340	340
1064	360	360
1065	370	370
1066	375	375
1067	381	381
1068	387	387
1069	395	395
1080	471	

SP 11660A

Data for Dam at Outlet of Subarea A-2

Name of Dam: CAMPBELLS LEDGE Sheet 2 of 3

Outlet Works Rating:	Outlet 1	Outlet 2	Outlet 3
Invert of Outlet	1031.2		
Invert of Inlet	NOT AVAILABLE		
Type	16" dia. CIP		
Diameter (ft) = D	1.33		
Length (ft) = L	140		
Area (sq. ft) = A	1.396		
N	.014		
K Entrance	0.5		
K Exit	1.0		
K Friction* $= 29.1_N{}^2 L/R^{4/3}$	3.45		
Sum of K	4.95		
$(1/K)^{0.5} = C$	.449		
Maximum Head (ft) = HM	33		
$Q = C A \sqrt{2g(HM)}$ (cfs)	28.91		
Q Combined (cfs)	≈ 30		

* R = Hydraulic Radius = (Area/Wetted Perimeter) = D/4 for Circular Conduits.

Data for Dam at Outlet of Subarea A-2

Name of Dam: Campbells Ledge Sheet 3 of 3

Storage Data:

Elevation		Area (acres)		Storage million gals	acre-ft		Remarks
1031.4	= ELEVO*	0		0	0		
1061.0	= ELEV1	21.7	= A1	70	214	= S1	
1064.0		22.6		92	281		
1080.0**		28					

* ELEVO = ELEV1 - $(3S_1/A_1)$

** Planimetered contour at least 10 feet above top of dam

Reservoir Area at ~~Top of Dam~~ Normal Pool is 15 percent of watershed.

Remarks:

SUSQUEHANNA River Basin

Name of Stream: CAMPBELLS LEDGE CREEK

Name of Dam: CAMPBELLS LEDGE

NDI ID No.: PA-00649

DER ID No.: 40-19

Latitude: N 41° 21' 45" Longitude: W 75° 47' 25"

Drainage Area: 0.32 sq. mile

Data for Subarea: A-2 (see Sketch on Sheet C-4)

Name of Dam at Outlet of Subarea: CAMPBELLS LEDGE

Drainage Area of Subarea: 0.23 sq. mile

Subarea Characteristics:

Assumed Losses: 1.0-inch initial abstraction + 0.05 in/hr

The following are measured from outlet of subarea to the point noted:

L = Length of Main Watercourse extended to the divide = 0.61 mile

L_{CA} = Length of Main Watercourse to the centroid = 0.38 mile

From NAB Data: AREA 11 PLATE E

Cp = 0.62

C_T = 1.5

$Tp = C_T \times (L \times L_{CA})^{0.3}$ = 0.97 (hrs)

Flow at Start of Storm = 1.5 cfs/sq. mile x Subarea D.A = .35 cfs

Computer Data:

QRCSN = -0.05 (5% of peak flow)

RTIOR = 2.0

Remarks: _____

APPENDIX C

SUMMARY

	DAM Subarea	STRIP MINE Subarea	Subarea	Subarea	Total
Drainage Area (sq. mile)	0.23	N/A			
	+ 0.09	FROM CANAL			
PMF:					
Peak Outflow (cfs)	N/A	N/A			
Total Runoff (inches)	N/A	N/A			
Dam at Outlet?	N/A	N/A			
Is Dam Overtopped?	N/A	N/A			
Depth of Overtopping (ft)	N/A	N/A			
One-Half PMF: = SDF					
Peak Outflow (cfs)	586	214			
Total Runoff (inches)	11.4	N/A			
Dam at Outlet?	YES	STRIP MINE			
Is Dam Overtopped?	YES	YES			
Depth of Overtopping (ft)	0.23	.08			
Does Dam Fail?	N/A	N/A			
Peak Failure Outflow (cfs)	N/A	N/A			
At time (hrs)	N/A	N/A			
Spillway (percent of PMF)	43	N/A			

DOWNSTREAM SUMMARY

	Peak Water Surface Elevation Before Failure	After Failure	Remarks
Cross Section	NA	N/A	
Cross Section			
Cross Section			
Cross Section			
Cross Section			

SELECTED COMPUTER OUTPUT

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  17 OCT 78
**********************************
    1              A1                    CAMPBELLS LEDGE DAN
    2              A2                       CAMPBELLS LEDGE CREEK
    3              A3                          GFCC
    4              B    300       0       15        0        0        0        0        0       -4        0
    5              B1     5
    6              J      1       6        1
    7              J1    .5      .4       .3       .2       .1      .05
    8              K      0       2                                          1
    9              K1                 UNCONTROLLED RUNOFF INTO RESERVOIR
   10              M      1       1      .23                .32
   11              P             21.5      118      127      136      142      165
   12              T                                                        1.0      .05               .15
   13              M     .97     .62
   14              X     420     420      1.0
   15              K      1       2                                          1
   16              K1               ROUTE THROUGH RESERVOIR
   17              Y                                 1
   18              Y1     1                                                -1061       -1
   19              Y4  1061    1062     1063     1064     1065     1080
   20              YS     0     130      340      360      370      471
   21              SA    .01    21.7     22.6       28
   22              SE1031.4    1061     1064     1080
   23              SS  1061
   24              SD1063.7     2.7      1.5      750
   25              K      1       3                                          1
   26              K1               ROUTE THROUGH DOWNSTREAM SECTION
   27              Y                                 1
   28              Y1     1
   29              Y6    .06     .04      .06      899     1000     4000      .09
   30              Y7     0     1000     1300      920     1420      900     1423      899     1453      899
   31              Y7  1480      900     1550      920     2450     1000
   32              K      1       4                                          1
   33              K1               STRIP MINE
   34              Y                                 1
   35              Y1     1                                                -555.5
   36              SA    .01      86      107      141
   37              SE    555     560      570      580
   38              SS    569     100     .001      1.5
   39              SD    570     2.7      1.5     3500
   40              K      99
```

C-19

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .50	RATIO 2 .40	RATIO 3 .30	RATIO 4 .20	RATIO 5 .10	RATIO 6 .05
HYDROGRAPH AT	2	.23	1	636.	509.	382.	255.	127.	64.
	(	.60)	(	18.02)(	14.42)(	10.81)(	7.21)(	3.60)(	1.80)(
ROUTED TO	2	.23	1	586.	352.	311.	205.	95.	47.
	(	.60)	(	16.60)(	9.97)(	8.80)(	5.81)(	2.69)(	1.34)(
ROUTED TO	3	.23	1	589.	352.	311.	205.	95.	47.
	(	.60)	(	16.69)(	9.97)(	8.80)(	5.81)(	2.68)(	1.34)(
ROUTED TO	4	.23	1	214.	156.	0.	0.	0.	0.
	(	.60)	(	6.05)(	4.41)(	0.00)(	0.00)(	0.00)(	0.00)(

SUMMARY OF DAM SAFETY ANALYSIS

CAMPBELLS LEDGE DAM

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1061.00	1061.00	1063.70
STORAGE	219.	219.	278.
OUTFLOW	0.	0.	354.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	1063.93	.23	284.	586.	3.00	41.00	0.00
.40	1063.61	0.00	276.	352.	0.00	42.25	0.00
.30	1062.86	0.00	260.	311.	0.00	41.50	0.00
.20	1062.36	0.00	249.	205.	0.00	41.50	0.00
.10	1061.73	0.00	235.	95.	0.00	41.75	0.00
.05	1061.37	0.00	227.	47.	0.00	41.75	0.00

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	589.	899.3	41.00
.40	352.	899.2	42.25
.30	311.	899.1	41.50
.20	205.	899.1	41.50
.10	95.	899.0	41.75
.05	47.	899.0	41.75

C-21

SUMMARY OF DAM SAFETY ANALYSIS

STRIP MINE

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	555.50	569.00	570.00
STORAGE	0.	1002.	1108.
OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	570.08	.08	1117.	214.	17.50	65.75	0.00
.40	570.06	.06	1115.	156.	1.50	75.00	0.00
.30	567.45	0.00	843.	0.	0.00	0.00	0.00
.20	564.59	0.00	561.	0.	0.00	0.00	0.00
.10	561.52	0.00	278.	0.	0.00	0.00	0.00
.05	559.89	0.00	135.	0.	0.00	0.00	0.00

SUSQUEHANNA RIVER BASIN

CAMPBELLS LEDGE CREEK, LUZERNE COUNTY

PENNSYLVANIA

CAMPBELLS LEDGE DAM

NDI ID No. PA-00649
DER ID No. 40-19

PENNSYLVANIA GAS AND WATER COMPANY

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

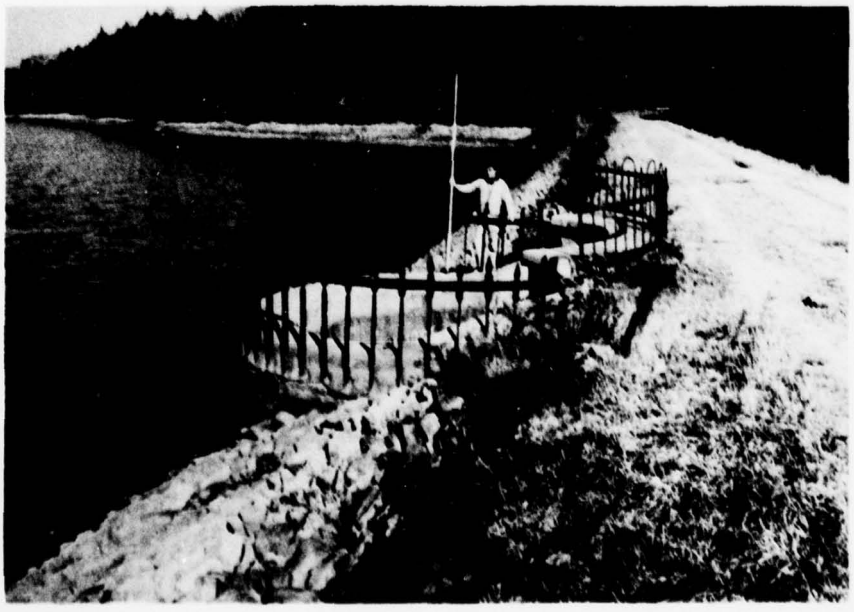
JANUARY 1979

APPENDIX D

PHOTOGRAPHS

CAMPBELLS LEDGE DAM

A. South Embankment - View from Right Abutment.



B. Spillway.

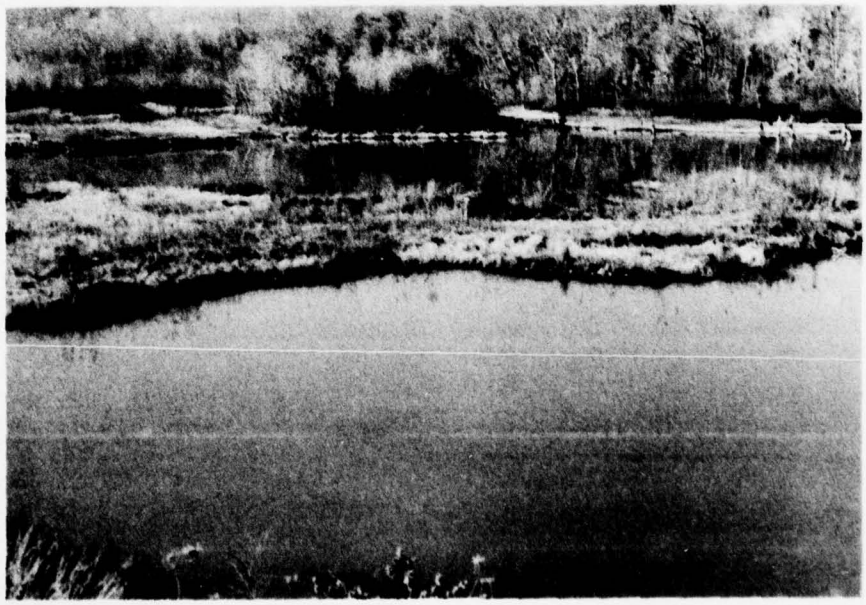
C. Spillway and Outlet Works Outlet

D. Downstream Channel.

E. North Embankment - Upstream Slope.

F. North Embankment - Downstream Slope.

G. Canal Flowing into Campbells Ledge Dam.



H. Abandoned Strip Mine at End of Downstream Channel.

SUSQUEHANNA RIVER BASIN

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PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JANUARY 1979

APPENDIX E

GEOLOGY

CAMPBELLS LEDGE DAM

APPENDIX E

GEOLOGY

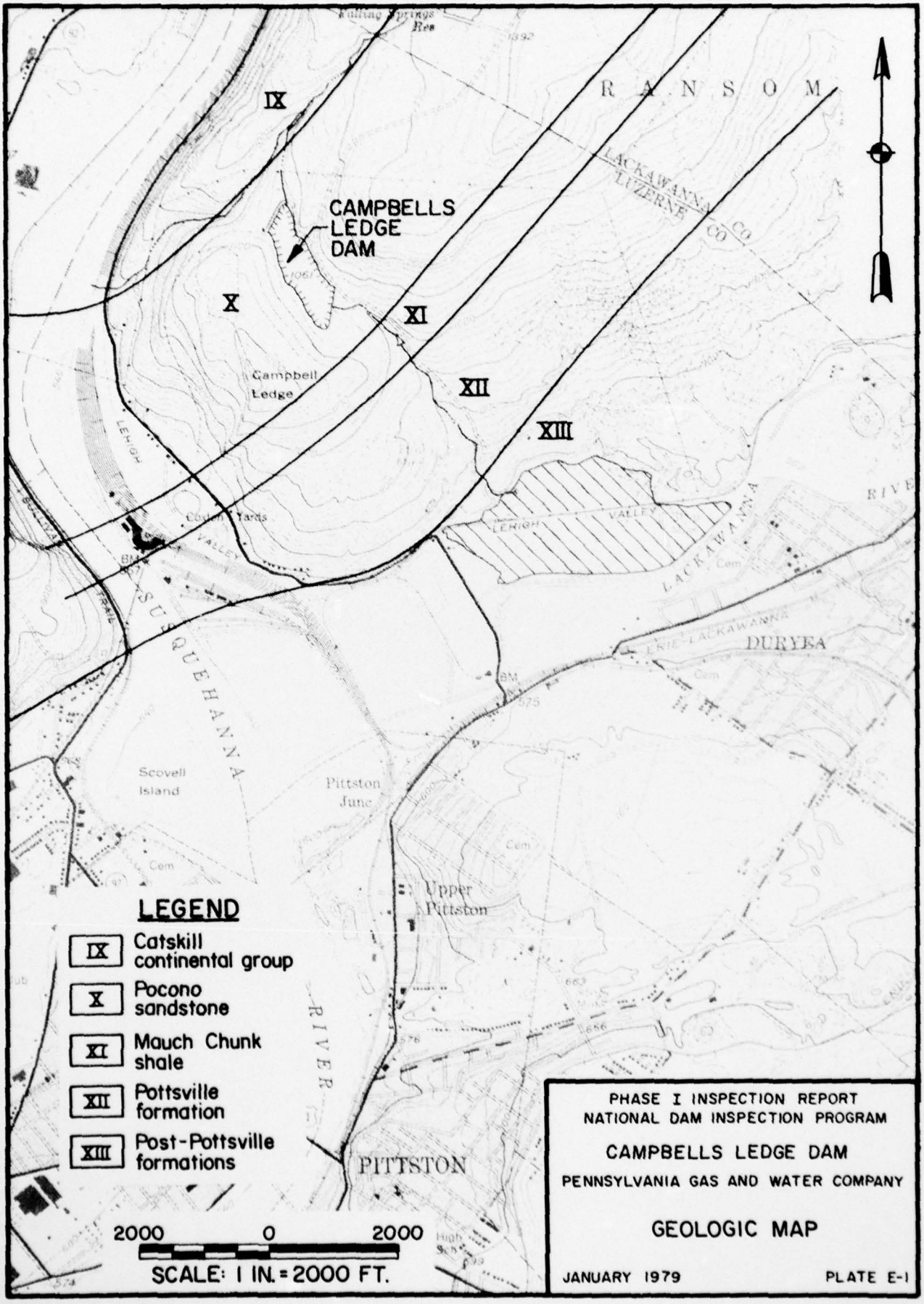
1. General Geology. The damsite and reservoir are located in Luzerne County. The rock formations exposed in Luzerne County range from the Post-Pottsville formations, of Pennsylvanian Age, down to the Onondaga formation, of Middle Devonian Age. The Wisconsin terminal moraine crosses the southern part of the County, and the greater part of the County is covered by glacial drift. Extensive deposits of glacial outwash occur along the Susquehanna River and less extensive deposits along the smaller streams.

Nearly all of Luzerne County lies in the Valley and Ridge Province in which nearly all the rocks have been strongly folded. In going from north to south across the County, five major folds are encountered, all of which trend northeast. The first of these is a shallow syncline on the crest of North Mountain, forming the Mehoopnay coal basin. The second is the Milton Anticline, which exposes the Portage group in the northwestern part of the County and gradually flattens out toward the northeast. The third and most pronounced is the Lackawanna Syncline, which originates in Lackawanna County to the north, and has preserved the post-Pottsville formations throughout the Wyoming Valley. The maximum depth of this syncline is reached in the vicinity of Wilkes-Barre and Plymouth. The double rim of this syncline is formed by the resistant Pottsville formation and Pocono sandstone, separated by the less resistant Mauch Chunk shale. The fourth fold is the Berwick (Montour) Anticline, which exposes a few feet of the Onondag formation in the vicinity of Beach Haven. This fold reaches its maximum development farther west and only the eastern portion reaches Luzerne County. The fifth major fold comprises a series of anticlines and synclines forming the Eastern Middle Anthracite Field in the vicinity of Hazleton. The synclinal basins in this region are relatively shallow and there are large areas from which all coalbeds have been eroded.

The general dips of the region vary from 0° to 40°, and the maximum dips are found on the rims and within the synclinal coal basins. The relatively soft post-Pottsville beds in their cores are severely folded and contorted with numerous minor faults. The northern and eastern-most parts of the County border the Appalachian Plateau

Province and are characterized by horizontal, or nearly horizontal strata. The Catskill continental group of rocks underlies those parts of Luzerne County that are outside of the five major folds.

2. Site Geology. The dam and reservoir are sited in an eroded shaley depression in the Pocono sandstone formation northwest of the Lackawanna Syncline and the Lackawanna River into which the area drains. The Susquehanna River is located about 3000 feet to the north and west of the reservoir and the confluence of the Susquehanna and Lackawanna Rivers is located 4000 feet to the south of the reservoir. The Pocono rock in the depression is apparently a hard, brown, horizontally stratified sandy shale, which is less resistant than the hard gray sandstone of the Pocono formation which surrounds it and forms the peaks and ledges of the mountainous drainage divide. Since the reservoir is located in a mountain top depression, it was necessary to construct an upstream dike in order to prevent the stored water from spilling over the divide and entering the Susquehanna River by way of Falling Springs Creek. A diversion canal has been cut through the red shale of the Catskill formation, located to the immediate northwest of the Pocono formation, in order to permit water from Falling Springs Reservoir to be diverted into Campbells Ledge Reservoir through a controlled intake. The water from Campbells Ledge Reservoir flows to the southeast by a steep natural channel that has been eroded through the Mauch Chunk, Pottsville and Post-Pottsville formations into the Lackawanna River. Extensive strip mining has taken place in the Pottsville and Post-Pottsville formations at the downstream end of the channel.



PHASE I INSPECTION REPORT
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CAMPBELLS LEDGE DAM

PENNSYLVANIA GAS AND WATER COMPANY

GEOLOGIC MAP

JANUARY 1979 PLATE E-1